POWER PLANT ENGINEERING

Established Over 32 Years

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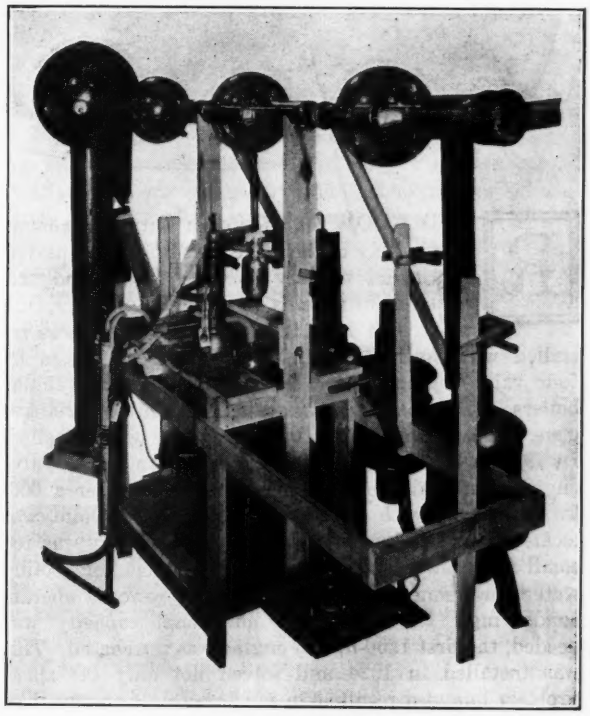
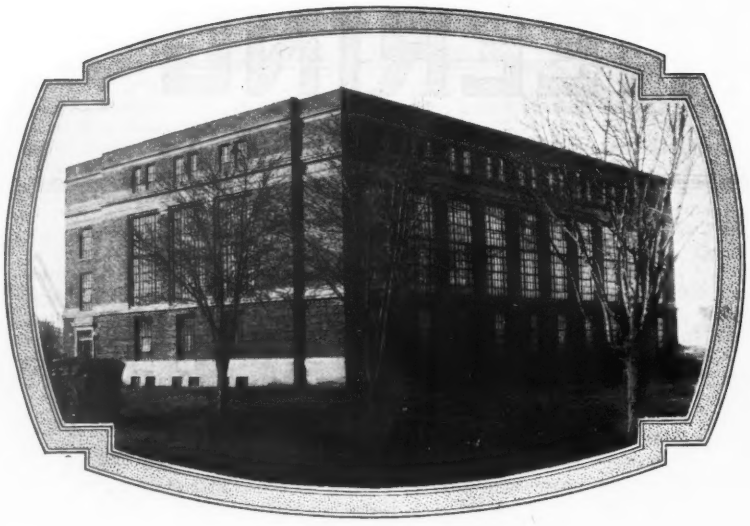


A Super Machine Gun

HERE IS AN OUTFIT that would bring joy to the heart of any gun-toting bootlegger. No, it isn't a still, it's a sort of machine gun, but O Boy, what a machine gun! Think of firing bullets at the rate of 5000 million million per second and imagine the damage they could do traveling at *175,000 mi. per second.*

"Applesauce," you say. "It can't be done. Stop your spoofing and come to earth."

But it can be done and *is* being done and we won't take back a word of what we said. Of course, the contraption pictured above isn't really a machine gun—we just used the machine gun idea to get you to read this—but it does fire projectiles at a speed 350,000 times faster than a rifle bullet. For this apparatus is one of the new Coolidge triple cascade cathode ray tubes which we described in our March 15 issue. Its bullets are electrons. These electrons are interesting little things and we would like to tell you more about them but its a long story and we don't want to start anything we can't finish. If you are interested, however, we refer you to the series of articles on the nature of electricity starting in this issue. They will discuss the electron at length and will explain just how this tube works.



Municipal Diesel Lighting Plant Is Enlarged

PONCA CITY INCREASES CAPACITY OF ITS DIESEL LIGHTING PLANT TO 5000 HP. AND ITS OUTPUT OVER FOUR TIMES WITHIN 6 YR. BY R. L. BALDWIN*

RAPID GROWTH of Ponca City, Oklahoma, due largely to the thousands of men employed in the oil refinery industry, influenced frequent enlargements in its municipal lighting plant. In 1912 its first power plant was installed with 75-kw. and 100-kw. generators driven by four valve engines served by horizontal return tubular boilers, using gas or oil as a fuel. In 1917, a 200-kw. generator, connected to a uniflow engine was installed. In 1919, a 400-kw. generator, connected to a four-valve engine, was added and two or three years later a 600-kw. generator with four-valve engine. The plant was located near the business district on a lot that was too small for growth and did not provide room for cooling water towers necessary if the engines were to operate condensing. In 1923, when additional capacity was needed, the first 1250-hp. oil engine was purchased. This was installed in 1924 and solved not only the space problem but also resulted in much better economy than had been obtained before. In 1925 the power needs were such as to demand an additional engine and a second 1250-hp. oil engine was purchased, which was installed in 1926.

*Burns & McDonnell Engineering Co.

COST REDUCTION WITH RAPID GROWTH

Expense, as given in the accompanying table, includes generating costs, distribution costs and depreciation. The generating costs per kw-hr. produced have been reduced, within the six-year period, to less than one-half of the original cost. The rapid growth continued and in 1927 it was found that the present site had reached its limit of development. A study was then made of various proposed locations for a new power plant. A site located on a railroad in the outskirts of the city was selected. This provided sufficient space for future growth and for storage of oil and construction materials for the water and lighting departments. It was decided to purchase and install two additional 1250-hp. engines with generators at this new site

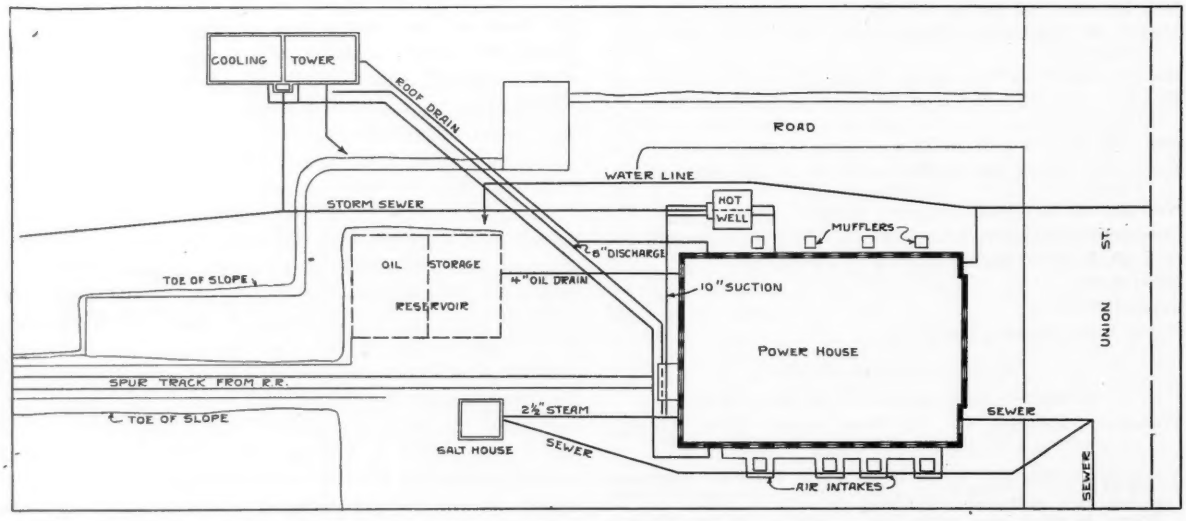


FIG. 1. GENERAL LAYOUT OF POWER PLANT GROUNDS SHOWING RELATION OF COOLING TOWER, OIL STORAGE RESERVOIR AND SALT HOUSE TO POWER PLANT

and put them into operation, tying them into the present power plant, and then have the two present 1250-hp. engines overhauled and later erected in the new power plant, making a total installed capacity of 5000 hp. in four identical units. The Diesel engines drive 850-kw., 2300-v., 60-cycle, 3-phase generators at a speed of 180 r.p.m. Three of the units have direct connected exciters. In addition, there is a 100-kw. motor-generator set, which will ordinarily be used for excitation.

In locating the structures on the selected site, it was considered important that the building be so faced that the prevailing south wind would provide utmost ventilation. Second consideration was given to the railroad spur and the question of future extension. Space had to be provided for the unloading and storage of fuel oil, for salt for the water softeners, and for the storage of construction materials such as pipe and poles. The cooling tower was placed as far away from the main building as practical as it was desired to get the full advantage of the breezes and at the same time keep the wet mist away from the other structures. The engines are housed in a brick building with structural steel frame on a concrete foundation. The building is 131 ft. 4 in. long by 86 ft. 10 in. wide by 59 ft. high. This height includes a full 12-ft. basement. An electric crane, having clear head room, is provided for handling repairs and for erection of equipment.

In order that it could be served by the existing sewers, the power house was set high. The railroad spur could also then be graded to permit freight or tank cars to stand without blocking the wheels and it was kept as near to the finished surrounding grade as possible in order to enable it to be crossed easily by trucks. The railroad level is just 4 ft. below the main engine room floor level, thus permitting the location of numerous basement windows, which resulted in a light basement. The power house was built without partitions. Past experience had shown that damage resulted from vibration and the suction effect due to unmuffled air intakes. So it was decided to use structural steel frame that would withstand all stresses.

Originally, the power house had the 1250-hp. engines spaced on 16-ft. centers, with a small, dark, inaccessible basement at one end of the engines. The basement housed the lubricating oil strainers, air compressor coolers and oil tanks. Concrete pit exhaust mufflers were used; Reed unit air cells were used on the intake and on the roof. The 19,000-gal. fuel oil tank was of concrete and was located under one of the city streets. As a result of the operator's experiences, it was found best to set the engines in the new building on 24-ft. centers with a basement under the entire building. By this means, it would be possible to replace the 1250-hp. engines with 2500-hp. engines when it becomes desirable to increase still further the capacity of the plant. This necessitated using a crane span and height suitable for the larger engines and providing a balcony level for the tanks that would go with the larger engine.

The present building will house the four 1250-hp. engines and provide space for an additional 2500-hp. engine. There is room left for extension of the building to accommodate three additional units, so that the layout has a maximum ultimate capacity of eight 2500-hp. engines or 20,000 hp. To get the desired ventilation, a large monitor was provided and the walls fitted with ventilated steel sash. A 10-t. floor-operated crane with electric hoist was provided.

TABLE SHOWING RAPID GROWTH OF PLANT AND THE OPERATING COSTS AND INCOME DURING PAST SIX YEARS

Year	1922	1923	1924	1925	1926	1927
Income	$118,184	$138,352	$198,276	$236,069	$268,136	$322,648
Expense	54,647	65,653	87,984	90,894	112,047	125,157
Net Profit	63,537	72,699	110,292	145,175	156,089	197,491
Kw.hr. Produced	2,096,702	2,871,134	4,457,621	5,855,078	7,362,211	8,966,700
Switchboard cost per kw.hr.	0.0199	0.0161	0.0130	0.0086	0.0092	0.0082

From the structural standpoint, no unusual problems were encountered, as the soil was firm and dry. The steel frame is similar to that in mill buildings. There are four rows of steel columns, extending in an east and west direction. The two outer rows are encased in the brickwork. The interior rows carry the main roof trusses and the crane girder. Due to the building being a large shell, the wind stresses were given special consideration. All stresses from a south wind, for instance, are carried to the foundations through the two south rows of columns. No wind stresses were carried through the main roof trusses to the north columns. This condition was accomplished by providing a sliding support on one end of the trusses which allowed for expansion. East and west winds were taken care of in a somewhat similar manner.

Pressed steel of the rib type, covered with two ½-in. layers of insulation, was provided for the deck roof. This type of roof is extremely light and allows quite a saving in steel purlins, as well as in the initial cost of the roof. This roof should have a long life because the steel will receive a constant coating of oil from oil mist rising from the engines. In view of the permanence of the rest of the building, and the newness of this type of roof, it was considered best to design the trusses, columns and footings to take the weight of a more usual type of roof so it can be replaced if necessary.

Foundations for the engines were constructed with a clear space of 1 in. between them and the building to prevent the transmission of vibrations. In a former installation, the air intake had caused vibration of win-

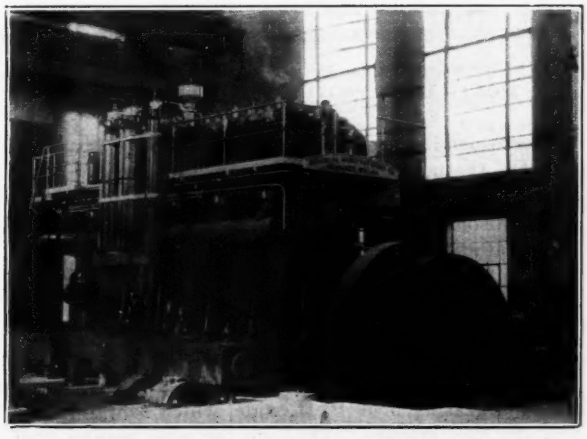


FIG. 2. INTERIOR VIEW SHOWING ONE OF FOUR 1250 HP. NORDBERG DIESEL ENGINES IN PLACE

dows in adjacent buildings. To prevent this a huge air intake muffler was constructed within the engine foundations. This muffler is in the form of a cylinder 6 ft. in diameter and 27 ft. 6 in. long, which is served with outside air through a 20-in. steel pipe. Despite the weight of the engines and the foundations, the loading on the soil is but 2500 lb. per sq. ft.

Between the two south rows of columns is a bay which contains an office, the switchboard and a machine shop. The office with glass partitions affording a view of the entire engine room, is located on an elevated floor above the front entrance at the engine platform level. proper height to become the operating level if 2500-hp. engines are used. With such engines, the fuel tanks would be set at the truss level. The capacity of the auxiliary fuel tanks is 900 gal. each, which is enough for about 10,000 kw-hr. per tank, or about a half day's run. All tanks are provided with overflows and sludge drawoffs and are arranged so that overflows and drawoffs will flow by gravity back to the concrete fuel storage tank through a 4-in. line. Individual cast-iron exhaust mufflers are provided for each engine as they were found to be more permanent, require less maintenance and give better service than a concrete muffler.

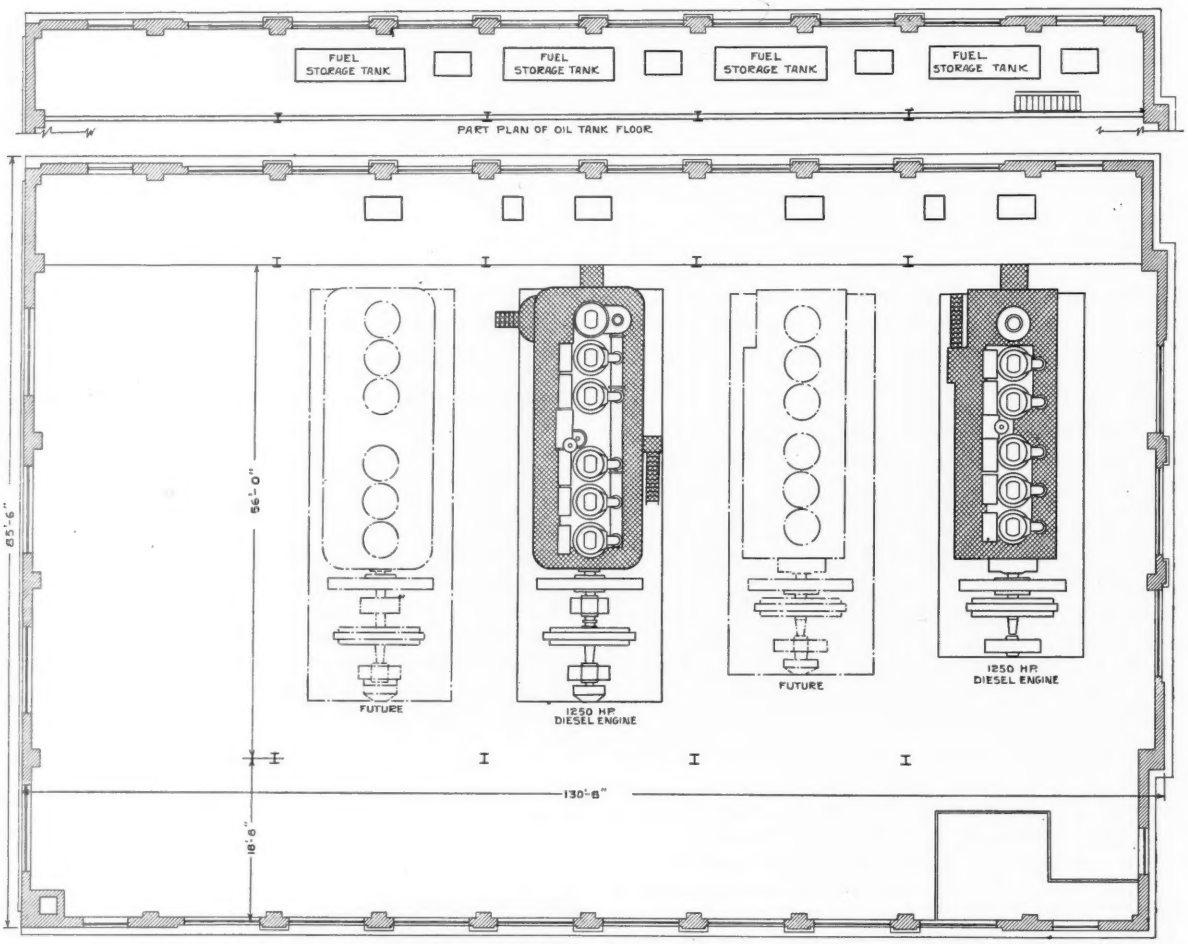


FIG. 3. PLAN OF OPERATING FLOOR SHOWING LOCATION OF PRESENT EQUIPMENT. BESIDES A SIMILAR ADDITIONAL UNIT, PROVISION IS MADE FOR PLACEMENT OF TWO OTHERS NOW OPERATING IN OLD MILL

The corresponding north bay houses the auxiliary tankage. On the main floor level is an auxiliary air compressor. The operating floor level in this bay connects to the various engine platforms. Since it is handy for the operators to make minor repairs here, the bay was made 10 ft. wide and checkered steel plate was used on the floor to prevent small tools from dropping through. This level contains a fuel oil filter for each engine and two light fuel oil tanks for starting.

On a still higher level, 23 ft. 5 in. above the main floor, is a grating floor 10 ft. wide, which contains four auxiliary fuel storage tanks, one for each engine, and four lubricating oil supply tanks. This level is the

Heating Problem Involves Many Angles

Ponca City is subject to temperatures below zero. Due to the extreme height, heating the building presented quite a problem, especially as it is necessary to keep the monitor windows open in winter to let out the oil vapors. In this connection it might be mentioned that an engine taking its air from within the building, while keeping the building cooler in summer, would make it harder to heat the building in winter.

Utilizing the waste heat of the exhaust was considered. One idea was to use a waste heat boiler inserted in the cast-iron mufflers for generating steam. A second method was to pass hot circulating water, taken from

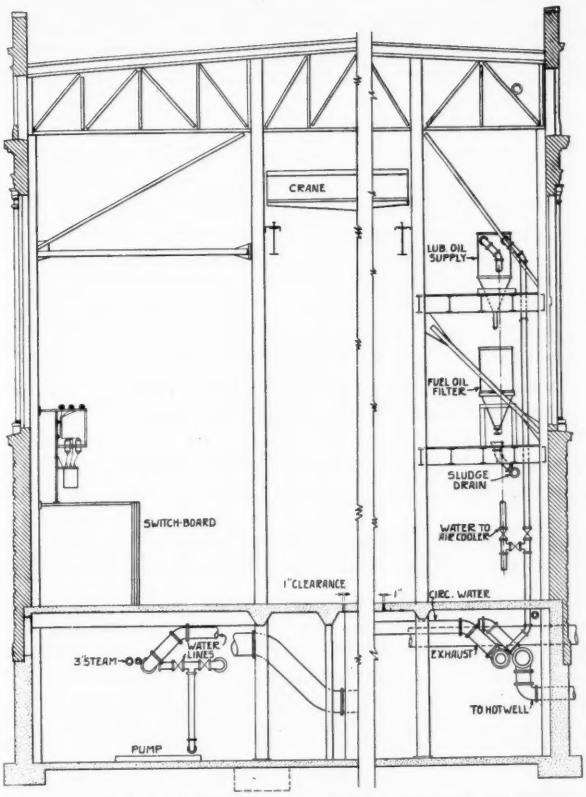


FIG. 4. CROSS-SECTION OF POWER HOUSE SHOWING PIPING CONNECTIONS AND RELATION OF LUBRICATING OIL SUPPLY TANK AND FUEL OIL FILTER TO SYSTEM

the engine outlet, through a steel pipe coil inserted in the muffler and circulating this through hot water radiators by a separate pump. It was found that the investment was not justified by the saving. Besides the complication of having the engines tied into the heating system, there was the trouble of removing the coils or boilers in summer time. Natural gas is available at low rates, so that a gas-fired boiler and regular steam radiation was then considered. Thirty horsepower of the boiler capacity would be needed for heating the fuel oil for unloading the tank cars in zero weather. The effective value of direct engine radiation presented a huge variable so that finally gas-fired radiators were used and these can be added as needed.

All air taken into each engine is filtered by 16 unit type Reed air filters. Each group is housed in a small brick structure at the ground level on the south side of building. Concrete paving and sod will prevent dust getting on to filter medium. Cleaning apparatus is provided in the basement.

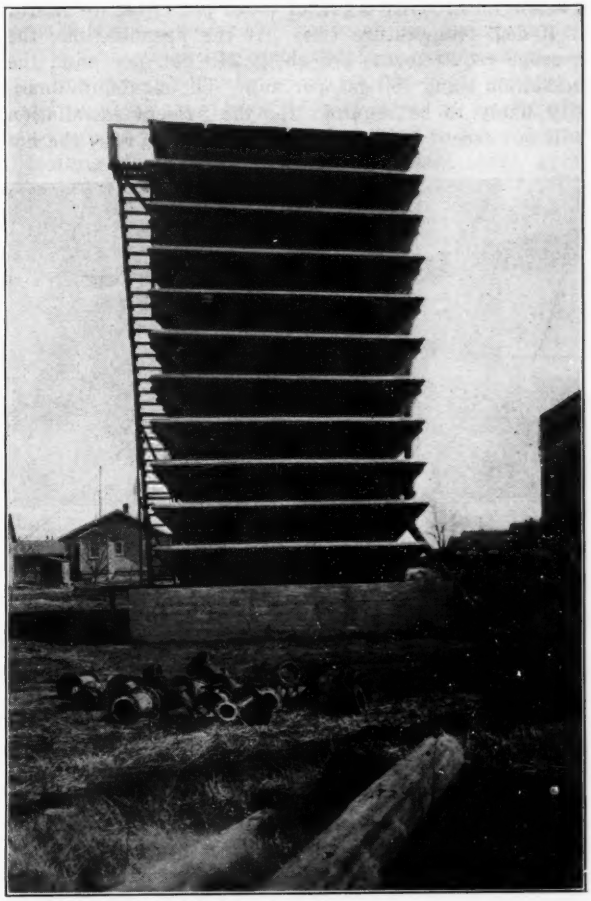


FIG. 6. COOLING TOWER SHOWING RELATION TO POWER HOUSE AT EXTREME RIGHT

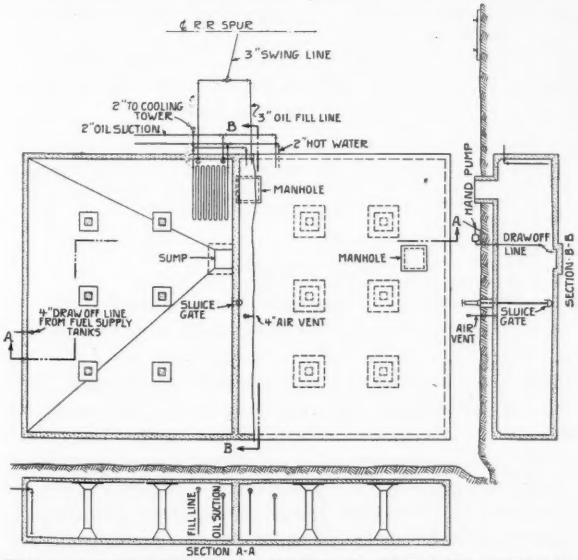


FIG. 5. CROSS-SECTIONAL VIEWS OF FUEL OIL STORAGE TANK

In order that advantage might be taken of a low market price on oil, a large concrete fuel oil storage tank was provided. It has a capacity of 200,000 gal., which is equivalent to 24 tank cars of oil, and sufficient to operate the plant under present conditions for three months. This tank is buried not only to avoid fire hazard but also to permit unloading the tank cars by gravity. The tank is divided into two compartments to facilitate cleaning. It is of the flat slab type of construction with 10-in. walls of ordinary concrete equivalent of 1:2:4. No attempt has been made to waterproof the tank other than to use good concrete. Duplicate motor-driven rotary transfer pumps are provided to fill the auxiliary oil storage tanks. Sludge and water are

removed by a hand-operated pump to prevent possible waste or fire hazard. The oil in the main storage tank near the transfer pump suction is kept warm by steam from a small vertical steam boiler in the basement of the main building.

The cooling system used is as follows: Water from the cooling tower is pumped through the engine and flows by gravity through a common header to a concrete hot well. From the hot well, water is pumped over the cooling tower. The city water system, which has an elevated tank near the power plant, is connected up as a standby supply. All makeup water is passed through a zeolite softener before entering the cooling system. The engines require 9 gal. of water per brake hp-hr. for a 40-deg. temperature rise. At the present time, the average requirements are about 240 gal. per min., the maximum being 480 gal. per min. The maximum quantity likely to be required for the present installation will not exceed 1000 g.p.m. At this latter rate, the hot well has a storage capacity of 16 min. and the cooling tower basin a 52-min. supply.

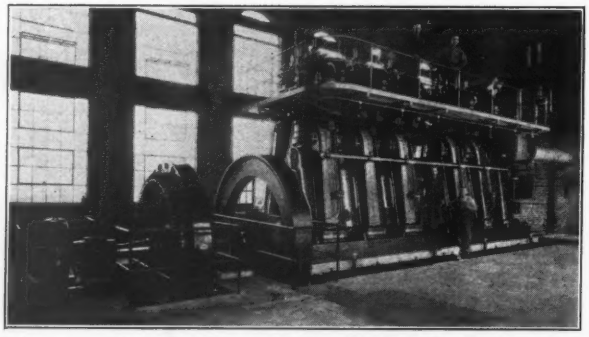


FIG. 7. ONE OF THE 1250-HP. ENGINES, NOW IN OLD POWER PLANT, WHICH IS TO BE INSTALLED LATER, IN NEW PLANT

Four 1000-g.p.m. motor-driven centrifugal pumps will be used for pumping circulating water. These pumps are rated for 80-ft. head. They are manifolded so that any pump may be used to pump either to the cooling tower or to the engine. Since the engine requires an 80-ft. head and the cooling tower requires only 45-ft. head, there is a waste of power due to throttling one set of pumps, but this is offset by the simplicity and reliability of operation. All main water lines are of cast iron and all pumps are submerged so as to avoid priming troubles.

Water Supply Is Augmented by Rainfall

The cooling tower, which is constructed of cypress wood, is of the atmospheric type. It has a capacity of 1000 gal. per min. when cooling water from 140 deg. to 90 deg. F. with wet bulb at 70 deg. F. and a 9-mi. per hr. wind. This tower is 66 ft. by 20 ft. wide by 33 ft. 6 in. high. It has 10 louvre decks and is arranged so that the upper seven decks need not be used in extremely cold weather. The piping is also valved so that the east half or west half of the tower may be shut down for cleaning. The tower basin is divided into two compartments to facilitate cleaning. The main building roof drains discharge into this basin. During heavy rains, it is estimated that 700 g.p.m. of soft water may be obtained in this way. Floats are provided in the power house for both hot well and cooling tower basin, so that the operator may balance the pumping without leaving the building. The city water, having a hardness of 14 gr. per gal., is softened by a zeolite softener. This softener is housed in a separate brick building.

Storage space is provided for storing a carload of salt at a time and the building is located alongside the tracks, so that salt may be shoveled directly from cars into the storage space.

Cost of equipment and buildings for which contracts were let are as follows:

Two 1250-hp. Diesel engines delivered	$154,400
Two 850-kw. generators and one exciter	13,377
One 100-kw. motor-generator set	2,889
Power house building (cost approx. 11c per cu. ft.)	113,260
Reservoir, hot well and cooling tower basin	10,700
Cooling tower	6,500

The power plant building, oil storage tanks, softening house and cooling tower basin were erected by the Interstate Construction Co. of Kansas City, Missouri. The wiring, pipe connections, and pole line to tie into present system is being handled by the city's own construction forces, under direction of J. W. Crow, Superintendent of the Water and Light Department. The plans and specifications for the new power plant were prepared by Burns & McDonnell Engineering Co. of Kansas City, Missouri, E. L. Ferguson acting as Resident Engineer during construction.

Principal Equipment at Ponca City Plant

DIESEL ENGINES

4 1250-hp., Nordberg Mfg. Co., Type 5-EG., 2-cycle, 180-r.p.m., five-cylinder with three-stage air compressor and combination force feed and gravity lubrication.

GENERATORS

2 900 and two 850-kw. at 80 per cent p.f., General Electric Co., 2300-v., three-phase, 60-cycle, 180-r.p.m., direct connected.
3 General Electric Co., 125-v., compound wound exciters, directly connected to main units.
1 100-kw., General Electric Co. motor-generator set with three-phase, 60-cycle, 2300-v. induction motor, direct connected to 100-kw., 125-v., d.c. compound wound generator.

SWITCHBOARD

4 General Electric Co. generator panels, 3 exciter panels, 1 regulator panel, 1 totalizing panel, 7 feeder panels.

WATER SUPPLY

4 5-in. Warren centrifugal circulating water pumps, 1000-g.p.m., against 80-ft. head, direct connected to 25-hp. General Electric motors, 1750-r.p.m.
1 1000-g.p.m. cypress wood cooling tower by Cooling Tower Company, Inc.
1 International Filter Company's zeolite water softener.

MISCELLANEOUS APPARATUS AND EQUIPMENT

2 1½-in. Gould rotary oil transfer pumps.
Nordberg Mfg. Co. air compressor, driven by 10-hp. motor.
4 Cast-iron mufflers by Nordberg Manufacturing Company.
1 Traveling crane, 10-t. capacity, single motor lift, 36-ft. span 53 ft., 3-phase, 60-cycle, 220-v.—H. D. Conkey & Company.
64 Reed unit air cells.
1 Fuel oil separator, De Laval 600.
1 Lubricating oil separator, Sharples No. 6.
1 Lubrbicating oil storage tank, 12-barrel capacity.

Pressure and Flow Control of Bleeder Turbines

FOUR CLASSIFICATIONS OF EXTRACTION TURBINES HAVE BEEN DEVELOPED TO MEET THE NEEDS OF VARIOUS INDUSTRIES. BY J. D. SCHMIDT*

TURBINES EQUIPPED for the extraction of steam for purposes other than heating of the unit's own condensate, may be grouped in four principal classes of application, each classification involving problems that affect the design of the extraction control mechanism. These four classes are: single bleeder for independent operation, single bleeder for parallel operation, double bleeder, and bleed-out-bleed-in units. There are, of course, other combinations which may be required but they are special cases and need not be considered here. Each of these applications offers a different problem and each problem is susceptible of solution in a number of ways.

Single bleeder turbines for independent operation offer the simplest problem. Here the requirement is merely that the bleeder control mechanism regulate the amount of steam admitted to the low pressure stage of the turbine. The speed responsive governor will then adjust the high pressure admission to suit the new conditions. The minor fluctuations in frequency due to the operation of the bleeder mechanism are usually not important where the unit is not required to operate in parallel with others on the same system.

The case of the single bleeder machine intended for parallel operation is a more complicated one. Here it is desirable not only that the amount of steam extracted be controlled, but that provision be made to adjust the admission of high pressure steam to compensate for fluctuations in the bleeder demand.

Double bleeder units, except for the duplication of the extraction control mechanism, present the same general problems as single bleeders, depending upon whether they are intended for independent or for parallel operation. Only one bleeder is compensated in such cases.

Turbines arranged for both extraction and induction of steam, if intended for parallel operation, require a compensating device to adjust the high pressure admission, because of the wide range of governor variation required between the condition of high pressure steam operation and induction steam operation, as well as other features dependent opon the particular application.

BOTH MECHANICAL AND HYDRAULIC CONTROLS HAVE BEEN DEVELOPED

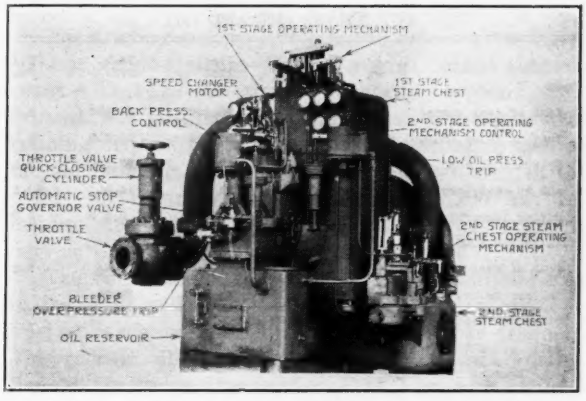
These problems, as mentioned in the first paragraph, are susceptible of solution in a number of ways and several such systems of control, both mechanical and hydraulic, have been applied with satisfactory results.

The hydraulic governing system lends itself to the design of simple and reliable devices for bleeder and induction control. One such system receives its actuating fluid directly from a centrifugal impeller mounted on the turbine shaft, while others employ a gear pump or rotary pump mounted on the fly-ball governor spindle which is driven from the main turbine shaft through the medium of a worm and gear.

In the case of the centrifugal impeller the pressure varies as the square of the rotative speed, and this pressure may be transmitted to a relay controlling the movement of an operating piston directly connected to the steam admission valve. For straight condensing service this speed responsive governor has numerous desirable features and is quite simple in construction.

For straight bleeder operation, the high pressure oil delivered by the impeller may also be employed to actuate an operating piston connected to the valve controlling admission to the low pressure stage of the turbine.

In the impeller type hydraulic governing system, control of the operating piston is provided by means of a relay actuated by the impeller pressure and regulated



BLEEDER TURBINE WITH VARIOUS PARTS INDICATED

by adjustment of oil back pressure on the end of the relay not subjected to the impeller pressure. The adjustment of this back pressure in the case of the bleeder control, is accomplished by means of a relief valve connected to a weight loaded diaphragm exposed to the pressure in the bleeder system.

FOR PARALLEL OPERATION BOTH GOVERNOR AND BLEEDER MECHANISM MUST BE REGULATED SIMULTANEOUSLY

For bleeder operation in parallel with other generating units, the needed compensation in high pressure steam admission may be obtained in similar manner by the use of two such relief valves, one to regulate the main turbine governor and the other the bleeder control mechanism. These valves are then arranged to be simultaneously operated by the weight loaded diaphragm described above in such manner that the high pressure admission is reduced when the low pressure admission is increased and vice versa. A shop view of a characteristic bleeder unit of two impulse stages is shown in the accompanying illustration.

This same system is employed in the case of turbines intended for extraction and induction. One such ma-

*Turbine Engineering Department, Westinghouse Electric and Manufacturing Co., South Philadelphia Works.

chine is designed to bleed out the entire steam flow at 125 lb. gage and to induct auxiliary exhaust steam at approximately 1 lb. gage into the reaction stage. The high pressure admission is, as usual, under the control of the speed responsive turbine governor. The low pressure induction is controlled by a constant pressure valve. There is also a governor controlled bypass valve by means of which steam from the impulse chamber may be admitted to the reaction stage.

In response to the pressure in the auxiliary exhaust line the constant pressure valve opens and will close of its own weight when the pressure is reduced. It is also inter-connected with the bypass governor in such a way that the latter can close the constant pressure valve if the machine tends to over-speed. A second constant pressure valve, set for somewhat higher pressure, is connected to the condenser and acts as a relief valve when the induction valve is closed by the governor.

Such a unit represents a special class of application and is not to be confused with the conventional, mixed pressure type machine, no mention of which has been made in the foregoing discussion.

Operating Experiences at Big Sioux Station†

Operating Results Confirm Designers' Conclusions That Powdered Coal Was the Ideal Method of Firing Steam Boilers Under the Prevailing Operating and Geographical Conditions. By J. E. Everson*

REASONS FOR selecting pulverized coal for Big Sioux Station were: greater physical overall boiler efficiency obtainable with the coals in this territory; greater flexibility of operation and greater economic overall boiler efficiency through being able to burn successfully any of the coals available at a truly competitive price in a wide field. Since starting operation in June, 1925, coal from 10 states, namely: Iowa, Kentucky, Illinois, Indiana, Arkansas, Oklahoma, Colorado, Missouri, Wyoming and Kansas have been burned. The variation was made more complete by the use of coal from several fields in each state.

TABULATED OPERATING RESULTS AT BIG SIOUX STATION FOR YEARS 1926 AND 1927

	Year 1926	Year 1927	Iowa Coal
COAL			
Tons of coal burned	54,540	61,920	5,796
Heating value, B.t.u. per lb.	10,986	10,610	9,180
Moisture in coal, per cent	9.45	10.15	15.6
Ash in coal, per cent	14.00	14.35	20.5
Fusing temperature of ash, deg. F.	2,200	2,200	2,260
COAL PREPARATION			
Tons of coal pulverized per mill hr.	7.41	6.84	7.25
Energy, kw.hr. per ton	20.60	20.70	
Steam for heating coal house per ton (Lbs.)	73	73	
Total operating, cents per ton (Includes labor, energy & material) Heating Steam Cost	26.75	26.08	
Total maintenance, cents per ton (Includes labor, material)	8.56	12.00	
BOILERS			
Avg. boiler rating, steam period, per cent	179	197	150
Boiler and economizer eff., per cent	81.3	82.9	82.0
Boiler eff., excluding econ., per cent	77.1	77.9	77.0

These coals varied in moisture content from 2 to 20 per cent, in ash from 9 to 24 per cent and in B.t.u. value per pound from 8700 to 15,800. To make the range greater, we have successfully burned petroleum coke braise having a heating value of over 15,000 B.t.u. per lb. and cinders as low as 2600 to 3000 B.t.u. per lb. As a matter of fact, we are seriously considering the use of cinders in connection with certain coal of fragile structure for the purpose of cushioning the pulverizing mills.

Average data and results for the calendar years 1926 and 1927 are given in the table. Figures in the last column are results from 150 cars of Iowa coal. From these data it can be seen that our costs per ton for preparing coal for burning was 35.31 cents in 1926 and 38.08 cents in 1927. With this added expense, together with the added carrying charges on the coal preparation equipment, it may seem doubtful whether the pulverized method of firing would show any advantage over stoker firing. For us the competitive field of coal buying is limited only by freight rates and other economic considerations as at this plant we are satisfied, after over two years' experience, that we can burn successfully and economically any coal that is offered at an attractive price.

Boiler Efficiencies of 83 Per Cent Obtained With Iowa Coal

Using Iowa coal, we have obtained boiler efficiencies as high as 83 per cent. We have not, however, been able to observe any advantage of Iowa coals over those from other fields, and there are certain disadvantages. The capacity of burning equipment has to be considerably greater than necessary for other coals because of its low B.t.u. content and the furnace volume has to be considerably larger than for other coals to obtain the high ratings without difficulties of slagging because of the high ash content. At Big Sioux this has meant limiting the boiler rating to 260 per cent with Iowa coal, as compared with 360 per cent say with Western Kentucky coal. Iowa coal also has the added disadvantage of being a poor coal to store for although we have stored Iowa coal for periods up to three months we do not feel that we have sufficient experience to recommend this practice.

Comparative coal prices cannot be based entirely on relative heat content because the cost of coal preparation will vary with different coals. The power consumption of coal mills increases with increased moisture and it costs just as much, perhaps more, to pulverize ash as it does to pulverize carbon. High moisture and ash content of Iowa coal shows that its price, to be com-

†Big Sioux Station described in detail in Oct. 15, 1925, issue of Power Plant Engineering, page 1034.

*General Supt., Sioux City Gas & Electric Co. Abstract of paper read before Iowa Power Conference.

petitive with other coals, must be lower than that based on a B.t.u. relation. Also the fact that each 1 per cent of moisture in the coal as fired decreases the boiler efficiency an average of 0.1 per cent should be borne in mind in comparing coals.

Ash in Furnace Aids Combustion

This decrease in efficiency, due to higher moisture content, is possibly almost if not completely overcome by the beneficial effects of the additional ash held in suspension in the furnace, the ash acting as a radiant and having a catalytic action aiding combustion.

We have recently changed the venting of the mills for the purpose of removing a larger portion of the moisture in the coal. Briefly, this consists of blowing flue gases into the mills for use as separation air and venting these gases through a cyclone separator, rather than having a closed circuit for the separation air of the mills. The purpose of this arrangement is to do more, or all, of the drying in the mills.

Recent improvements at Big Sioux Station include the installation of the fourth boiler. This boiler has water cooled side walls, an air preheater and forced draft fan in addition to the equipment of the boilers originally installed. Our limited experience with this boiler does not permit conclusions being drawn at this time. We have obtained 400 per cent rating on this unit and expect to exceed that rating in the future.

Aluminum Plant Increases Boiler Capacity

Careful Design of New Stoker-Fired Boiler Plant to Meet Fluctuating Rolling Mill Load and Constant Heating Load, Results in High Efficiency

COMBINATION OF AN extremely fluctuating steam load, caused by a rolling mill engine, and a fairly constant steam heating demand is not the easiest thing in the world for a boiler plant to handle economically. An extremely satisfactory solution to this problem has been obtained, however, at the new boiler house of Plant No. 1 of Aluminum Goods Mfg. Co., Two Rivers, Wisconsin, where such conditions prevailed. The new boiler plant, which is described here, has an equivalent evaporation of over 10 lb. water per lb. of dry coal fired and has handled these loads with perfect ease and no overworking of the equipment. In fact, with a light heating load, one boiler handles a load fluctuating between 25 and 225 per cent of its rating with no trouble.

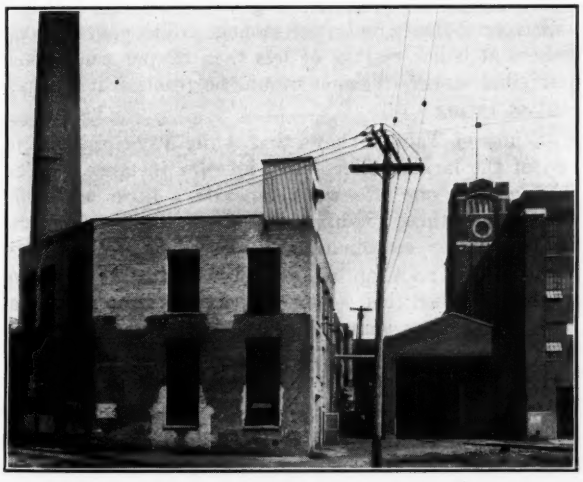


FIG. 1. EXTERIOR OF REMODELED BOILER PLANT, SHOWING HOW WALLS WERE RAISED 15 FT. TO ACCOMMODATE NEW BOILERS

As its name implies, this company makes all types of aluminum ware, the total produced by its various mills being 60 per cent of the aluminum ware made in the United States. The company has two mills at Two Rivers, Wis., and in 1926 it was considered advisable to rebuild the boiler plant at Plant No. 1, as described below, since the manufacturing buildings were being enlarged and a heating load equivalent to about 180 b.hp. added, which the old boilers could not possibly handle.

The existing rolling mill plant is driven by a Vilter 800-hp. single-cylinder Corliss engine, exhausting at about 6 lb. gage directly to the heating system. This exhaust was just about enough, when the engine was running at peak loads, to supply the heating system of the old building. This is the only prime mover in the plant; all other power needed—about 1200 kw. for motors, etc.—is purchased from the Wisconsin Public Service Co.

The rolling mills take pigs of pure aluminum cast in the plant and roll them into sheets, which are then worked into aluminum kitchen ware and other products. This rolling mill load causes large and violent fluctuations in the steam demand for about 3 hr. each at three regular periods during the 24 hr., as shown by the steam flow chart, Fig. 4-C. These peaks amount to about 600 i.hp. on the engine and between them the load drops frequently as low as 100 boiler hp.

TABLE I. RATINGS AT WHICH VARIOUS SIZES OF BOILERS WOULD OPERATE TO HANDLE VARIOUS TOTAL LOADS. (2 AND 1 INDICATE TWO BOILERS ON LINE, 1 OFF; 1 AND 1 MEANS ONE ON AND ONE OFF)

BOILERS	Per cent of Rated Horse Power at Load of						
	1000 b.hp.	850 b.hp.	700 b.hp.	600 b.hp.	450 b.hp.	300 b.hp.	100 b.hp.
3-250 hp. - 2 & 1	200	170	140	120	90	60	20
3-300 hp. - 2 & 1	166	142	116	100	76	50	16
3-350 hp. - 2 & 1	143	124	100	86	64	43	14
3-400 hp. - 2 & 1	125	106	87	75	56	37	12
2-300 hp. - 1 & 1	333	284	232	200	152	100	33
2-350 hp. - 1 & 1	286	248	200	172	128	86	28
2-400 hp. - 1 & 1	250	212	174	150	112	74	24
2-450 hp. - 1 & 1	222	190	154	133	102	66	22
2-500 hp. - 1 & 1	200	170	140	120	90	60	20

In the coldest weather, the heating load on the existing buildings absorbed all the exhaust from the engine operating at peak load. This was checked by a comparison of the coal burned in cold weather on Sundays with that burned in mild weather on week days when the engine was running. It was also checked by a rough calculation of the theoretical heating load on the existing buildings.

During 1924 and 1925, the average amount of coal burned per month was about 340 t., the maximum variations from this being 215 t. in June, 1924, and 571 t. in January, 1924. For the same two years the average boiler horsepower was 277 per month, the maximum being 465 in January, 1924, and the minimum 174 in June, 1924. These figures were calculated by assuming an evaporation of 7 lb. water per lb. fuel and 572 working hours per month.

With the additional buildings and a number of fresh air intakes planned, it was assumed that to take care of the increased total load, a continuous boiler load during severe weather would amount to 850 b.hp., while the average during the heating season would be about 400 b.hp.

The foregoing analysis having been made by the company and Lockwood, Greene & Co., Inc., who had been called in as consulting engineers, the next step was to determine the characteristics of the new boiler plant. To assist in determining the proper boiler installation, Table I was prepared to show the ratings at which various sizes of boilers would have to operate at various loads. A load of 1000 b.hp. was included to show the influence of future increase.

Judging by the company's previous experience, it was also decided that it was not desirable to operate the new plant at more than 175 per cent of rating for short peak loads, while for a steady all day maximum heating load, 150 per cent would be satisfactory. If the total load increases to 1000 b.hp. in the future, the boilers can be run up to 175 per cent of rating before adding another boiler. According to data obtained from certain stoker manufacturers, assuming small underfeed stokers with forced draft, it is not economical to operate such stokers at boiler ratings of less than 80 per cent, while maximum stoker efficiency would be reached at 175 per cent of rating.

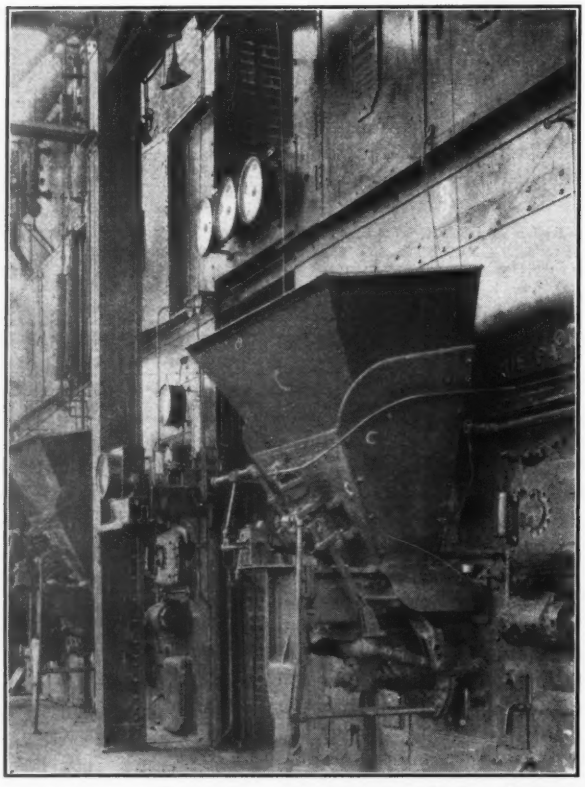


FIG. 2. STOKERS FIRING THREE NEW 300-HP. BOILERS ARE GOVERNED TOGETHER WITH FAN BY A REGULATOR TO MEET VARYING PRESSURE AND LOAD CONDITIONS

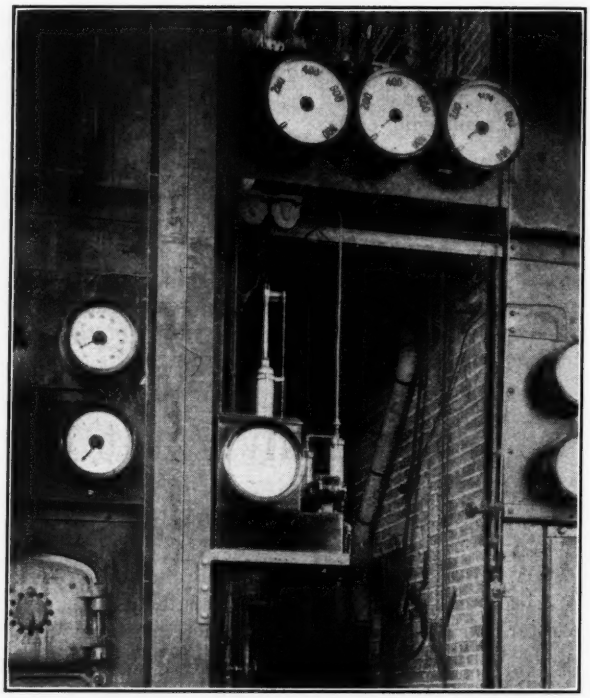


FIG. 3. STEAM FLOW INDICATORS AND CO_2 RECORDER BETWEEN BOILERS 2 AND 3; DRAFT INDICATORS ON EACH BOILER. LOAD ON NO. 1 BOILER VARIED SO FAST THAT FLOW METER INDICATOR NEEDLE DOES NOT SHOW

Study of Table I shows that while a combination of two of the larger boilers—500 hp., for instance, one on the line and one off—would operate a little more efficiently than three 250-hp. units, two on the line and one off, the latter combination would have greater flexibility. Also, addition of another boiler to the first two would cut down their efficiency. It was decided, therefore, to use three boilers instead of two.

This narrowed the choice somewhat; then the three 250-hp. units were ruled out because they would have to operate at higher ratings than is desired. The three 300-hp. boilers come within the desired limits and are somewhat more efficient than the three 350-hp. units. The latter, however, would allow a big increase in load before a fourth boiler would be required. It was finally decided on the basis of the above data, that three 300-hp. boilers would be the best combination to use under the circumstances and the design was made on that basis. It was the idea of the designers that the plant should be of standard, up-to-date design, as simple as possible and with no frills, yet giving performance of the highest economy. It was also felt that while sufficient instruments should be provided to determine this performance continuously, over-instrumentation should be sedulously avoided.

The new plant is shown in the accompanying photographs. It was necessary to raise the roof of the exist-

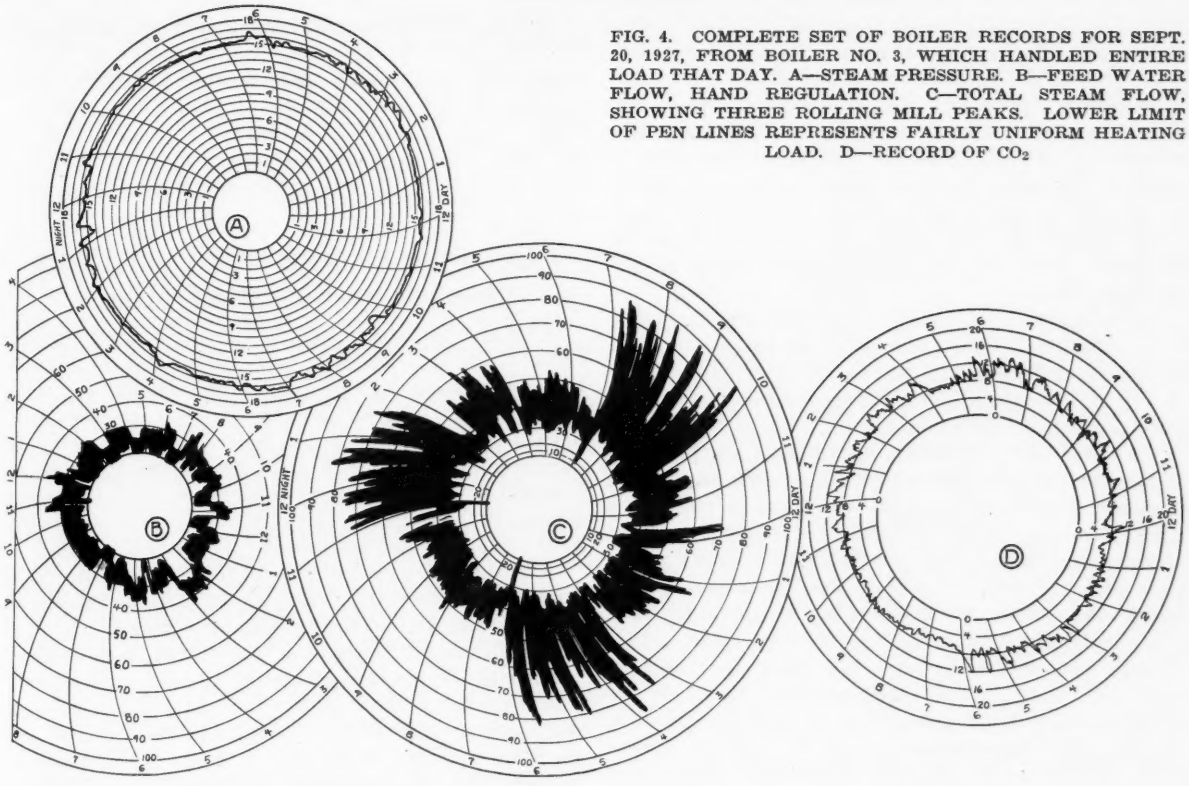


FIG. 4. COMPLETE SET OF BOILER RECORDS FOR SEPT. 20, 1927, FROM BOILER NO. 3, WHICH HANDLED ENTIRE LOAD THAT DAY. A—STEAM PRESSURE. B—FEED WATER FLOW, HAND REGULATION. C—TOTAL STEAM FLOW, SHOWING THREE ROLLING MILL PEAKS. LOWER LIMIT OF PEN LINES REPRESENTS FAIRLY UNIFORM HEATING LOAD. D—RECORD OF CO_2

ing boiler house 15 ft. and to take out one old boiler and install one new one at a time, so that complete steam service could be maintained to the factory at all times. Piling had to be put down and new foundations constructed for the new equipment. This work was all successfully accomplished in a short time and the new plant appears as shown in the photographs.

TABLE II. REPORT OF TEST ON BOILER NO. 1, ALUMINUM GOODS MFG. CO. PLANT NO. 1

Item	Description			Amount
1.	Grate surface			56 sq. ft.
2.	Water heating surface			3002 sq. ft.
3.	Duration of test			8 hours
4.	Kind of coal			W. Va. Splint—Nut and Slack
	AVERAGE PRESSURES AND TEMPERATURES			
5.	Steam pressure by gage			143.1 lb. per sq. in.
6.	Temperature of feed water entering boiler			175.3 F.
7.	Temperature of chimney gases at uptake			505.8 deg. F.
8.	Temperature of air entering fan			64 deg. F.
9.	Pressure in wind box			0.45 in.
10.	Draft over fire			0.04 in.
11.	Draft in uptake			0.31 in.
12.	Temperature of calorimeter			269 deg. F.
13.	Quality of steam			98%
14.	Temperature of steam			364.6 deg. F.
15.	Heat value of 98% steam corrected for feed water temp.			1035 B.t.u.
	TOTAL QUANTITIES			
16.	Weight of coal as fired			12,092 lb.
17.	Analysis of coal—Sample	1	2	Ave.
	Moisture	5.3%	6.0%	5.65
	Ash	8.0%	8.0	8.0
	Sulphur	2.3	1.9	2.1
	B.t.u.	12,840	12,780	12,810
	Combustible in ash	14.8	12.7	13.7
18.	Ash analysis moisture			8.16%
19.	Dry coal fired			11,409 lb.
20.	Total ash as weighed			1494 lb.
21.	Total dry ash			1370 lb.
22.	Combustible in ash			188 lb.
23.	Total water fed—266,661			121,700 lb.
24.	Total water evaporated corrected for quality			119,266 lb.
25.	Total equiv. evap. F. & A. 212 deg			127,257 lb.
25a.	Factor of evap			1.065
26.	Lbs. water per lb. coal 23 ÷ 16			10.06
27.	Water evap. per lb. dry coal 24 ÷ 19			10.45
28.	Equiv. evap. per lb. dry coal 25 ÷ 19			11.24
	EFFICIENCY			
29.	B.t.u. per lb. dry coal			13,577
30.	Eff. boiler, furnace and grate			80.5%
	CAPACITY			
31.	Evap. per hr. from and at 212 deg			16,150
32.	B.hp. developed			468
33.	Rated B.hp.			300
34.	Per cent capacity developed			156%

Dry saturated steam is generated by three Union Iron Works longitudinal-drum, water-tube boilers, each of 3000 sq. ft. heating surface, but without superheaters or economizers. These units are designed for 200 lb. pressure but are usually operated at 150 lb. gage. Each boiler is fired by a Combustion Engineering Corp. Type E stoker. Boilers are equipped with Reliance water columns, Diamond soot blowers, Vastine furnace fire observers, Crane safety and non-return valves, Hovalco Homestead blowoff valves and Crane fittings and piping throughout, with Johns-Manville insulation.

Coal is brought to the plant by truck, hoisted by a bucket elevator and distributed by a screw conveyor to overhead bunkers of 120 t. capacity in the boiler house. From these bunkers a 1000-lb. weigh larry delivers it to the stoker hoppers. Ash is taken out by wheelbarrows. All coal-handling equipment was supplied by Freeman Riff Co.

Forced draft for the stokers is supplied by a Clarage No. 90 fan, set on the firing floor, driven by a 7 by 7-in. Clarage steam engine. Fan and stoker speeds are controlled by a Ruggles-Klingemann regulator to maintain constant steam pressure. Flue gas passes out through a steel plate breeching, remodeled from the old one, to a 6 ft. by 115 ft. common brick chimney.

Refuse, paper, sawdust and the like are burned in a Kewanee firebox boiler, as attempting to burn this material in the main boiler furnaces lowers the efficiency of the stokers. This small boiler feeds steam at from 2 to 6 lb. directly into the heating system.

Feedwater, taken from the city mains, passes first

through a Permutit pressure filter and a Colles heater and purifier of 70 g.p.m. capacity. From here it is fed to the boilers by two American Marsh 10 by 6½ by 12-in. outside-center-packed, simplex, steam-driven boiler feed pumps. Each boiler is fitted with a Metropolitan injector for emergency service and feedwater level is regulated by hand. Returns from the heating system are brought by an American Marsh vacuum pump back to the heater. The fan engine and pumps exhaust to the heater with bypasses for the excess steam to the heating system.

A Buffalo 18 by 10 by 12-in. Underwriters fire pump has a capacity of 1000 g.p.m. at 70 r.p.m. Compressed air for the factory is supplied by an Ingersoll-Rand, 12 by 7½ by 12-in., 2-cylinder, 2-stage air compressor, belt driven by a G.E. induction motor.

As noted above, sufficient instruments are provided in the new plant to give all necessary data on its performance over a given period. In the chief engineer's office is a gage board carrying a Crosby recording pressure gage, with Marsh and Federal indicating gages. Each boiler is equipped with a pressure gage, an indicating flow meter, an indicator for windbox pressure and one for draft over the fire. Besides these, a CO_2 recorder is installed that may be connected to each or all of the boilers. These boiler instruments, which are all Republic, are mounted as shown in Figs. 2 and 3, the three flow meters being set together between boilers 2 and 3, with the CO_2 recorder below them. The steam flow is recorded and integrated by three Republic recorders, while a fourth recorder takes account of boiler feed water.

Figure 4 shows a typical set of charts from these recorders, all for the same day, for boiler No. 3. The steam flow record shows how the violent fluctuations of the rolling mill load come on at three periods: 7-10 a. m., 3-6 p. m., 11 p. m., 2 a. m. Comparison of this with the corresponding records of CO_2, steam pressure and feedwater flow is of interest.

Since weight of coal burned is measured by the boiler room weigh larry and amount of water fed to boilers by a flow meter, the actual evaporation can be quickly determined for any period. This averages well over 10 lb. water per lb. of fuel.

When the last boiler was installed in the plant in 1927, a test was run on No. 1 boiler by Lockwood Greene & Co., Inc., co-operating with engineers of the boiler and stoker manufacturers. This test, detailed in Table II, showed that with W. Va. splint (nut and slack) the usual fuel, having a heat value of about 12,800 B.t.u. per lb. and other constituents as shown, this boiler, furnace and grate had an average efficiency of 80.5 per cent for an 8-hr. test at a boiler rating of 156 per cent. For this period the actual evaporation per pound of dry coal fired was 10.45 lb. while the equivalent was 11.24 lb.

At the time Fig. 3 was taken, the heating load was not heavy but the rolling mill load was on. Boiler No. 1 was carrying this entire load; the needle of the left hand steam flow indicator was swinging between 100 and 500 about twice a minute and the only sign of this fluctuation manifested by the equipment was a momentary speeding up and slowing down of the fan. That is why the No. 1 flow meter appears to have no hand; it was moving too fast to show in a time exposure.

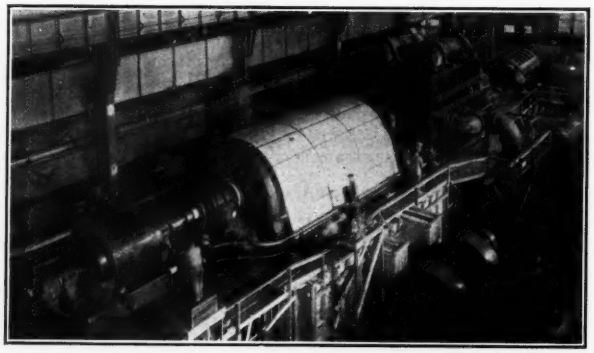
Design of the plant described above was carried out by Lockwood, Greene & Co., Inc., in charge of W. F. Dolke, Jr., co-operating with George Anderson, chief engineer of the No. 1 and No. 4 plants of Aluminum Goods Mfg. Co. and G. A. Magee, superintendent of the plant. We are indebted to these men for data and the most cordial co-operation in preparing this article.

Clinkering Characteristics of Coals Studied by Bureau of Mines

CLINKERING CHARACTERISTICS of coal and the properties of the coal ash have been studied by the United States Bureau of Mines to determine whether any relationship exists between the two. A few coals have been burned in a large heating boiler and the resultant clinker measured. Such tests have been too few in number to warrant general conclusions, but they show reasonable concordance between clinker measurements of the experimental furnace and the heating boiler.

Clinkering characteristics of coal determine to a large extent the relative availability and usefulness of the coal and the operating cost of a boiler room. It requires, however, very close observation and detailed records to be able to separate the troubles and expense due to the ash in the coal from those caused by the burning characteristics of the combustible and the size and physical condition of the coal as fired. The method of burning and the mechanical equipment are additional factors which make it difficult to generalize. The work being carried on by the Bureau of Mines is of extreme importance. Results of the work already published have been encouraging and it is expected that further experiments will confirm conclusions drawn from earlier tests.

Large Long Beach Turbo-generator Unit on Test



GENERAL VIEW SHOWING THE 94,000-KW. TURBO-GENERATOR FOR THE LONG BEACH STATION OF THE SOUTHERN CALIFORNIA EDISON CO. ON TEST AT THE SCHENECTADY WORKS OF THE GENERAL ELECTRIC CO. THIS SHOWS THE TURBINE, THE MAIN GENERATOR, THE SERVICE GENERATOR AND THE EXCITER

ACCORDING TO A recent report from the Department of Commerce, commercial stocks of bituminous coal on January 1, 1928, amounted to 55,500,000 t. On October 1, 1927, the date of the last previous survey, the stocks were 61,900,000 t.

Detroit Edison Co. Will Supply Steam to New Fisher Bldg.

STEAM LINE 6000 FT. LONG TIES GENERAL MOTORS STEAM PLANT AND GRAND BLVD. DISTRICT TO DETROIT EDISON CO. DISTRICT STEAM SYSTEM TO FURNISH STEAM FOR GENERAL MOTORS BLDG. AND NEW FISHER BLDG. BY GLEN D. WINANS*

ABOUT April 1, The Detroit Edison Co. began construction of an extension from the present steam distribution system to serve heating business in the Grand Boulevard heating district of Detroit, Mich. This extension will consist of 6186 ft. of 16-in. pipe laid in a 4-in. concrete conduit and about 900 ft. of 8-in. return line. This extension will serve the present General Motors Building, the new Fisher Building which is under construction and other smaller buildings. The accompanying map will show the district served.

In addition to the extensions to the distribution system, the company has purchased the heating plant of the General Motors Co., to be known as the Boulevard Heating Plant. The distribution system will be fed from this plant as well as from the present Willis Avenue Plant.

The General Motors Building has a steam demand of 63,000 lb. per hr., and uses steam for the heating requirements of the building and a small amount for processes. It is estimated that the Fisher Building will have a steam demand of 70,000 lb. per hour and will use steam for heating the building and water for domestic purposes only. The following is a brief specification of the 16-in. steam line, details of which are shown in the accompanying sketch:

Pipe: 16-in. O.D. steel pipe with 3/8-in. wall thickness.

Joints: To be welded except at fittings.

Fittings: To be cast iron, 250 lb. standard.

Expansion joints: Single slip type; where passing under a viaduct, corrugated joints will be used to eliminate manholes.

Valves: Non-rising stem, solid wedge gate valves. Cast-iron body, bronze mounting, 250-lb. standard.

Anchors: Cast-steel straps, with stops welded to the pipe.

Guides: Cast-steel straps similar to the anchors, located 10 ft. from the slip joint.

Insulation: 1½-in. laminated asbestos, with a waterproof jacket.

Traps: Float type.

Ordinarily the condensation from building heating systems is not returned to the plants because of the high cost of construction necessary to return a comparatively small amount of condensation. But because of the size of the Fisher and General Motors buildings, it will be desirable to return the water of condensation from these buildings to the plant. To return this condensation a separate 8-in. cast-iron pipe line will be laid from the Fisher Building to the Boulevard Plant. Into this will be discharged also the condensation from the General Motors Building. This line will be laid in the same trench as the 16-in. line in Second Boulevard, with a 4-in. concrete dividing wall.

*Engineer of Steam Distribution, The Detroit, Edison Co.

Tunnels, ////; steam lines, ———.

MAP OF COMPLETE DISTRICT HEATING SYSTEM OF DETROIT EDISON CO., SHOWING HOW THE LONG LINE NOW UNDER CONSTRUCTION EXTENDS THE SYSTEM TO THE NEW FISHER BLDG. AND TIES IN THE FORMER GENERAL MOTORS STEAM PLANT. INSERT—CROSS SECTION OF NEW HEATING MAIN

In the Boulevard Plant there are four 500-hp. boilers and room enough on the property to install four additional 1300-hp. boilers. This plant has its own coal handling equipment, so that coal can be brought in by rail, crushed and delivered to the bunkers at the plant without trucking.

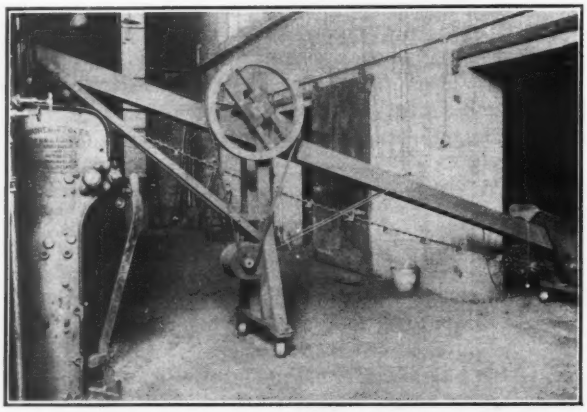
Before it will be needed for the heating season of 1928-29, boiler No. 6 at Willis Avenue Heating Plant will be ready for operation. This will be a 2565-hp. Stirling "W" type boiler.

Portable Conveyor Fills Stoker Hoppers

LIGHT MOTOR-DRIVEN CONVEYOR IS USED TO ADVANTAGE IN POWER PLANT OF SOUTHERN BAPTIST THEOLOGICAL SEMINARY AT LOUISVILLE, KENTUCKY

ON THE CAMPUS of the Southern Baptist Theological Seminary at Louisville, Ky., a new boiler plant for heating purposes has recently been constructed and put into service.

Three Vogt four-drum, 165-hp. boilers, fired by Huber stokers, are installed with space provided in the



THIS PORTABLE CONVEYOR ELIMINATES UNNECESSARY COAL HANDLING IN THE BOILER ROOM

building for a fourth unit. The boiler room floor is 12 or 15 ft. below the ground level and coal, received by truck, is dumped through manholes direct to the inside coal storage provided at the same elevation as the boiler room floor. The coal storage is separated from the boiler room by concrete walls and fireproof doors, as shown in the illustration.

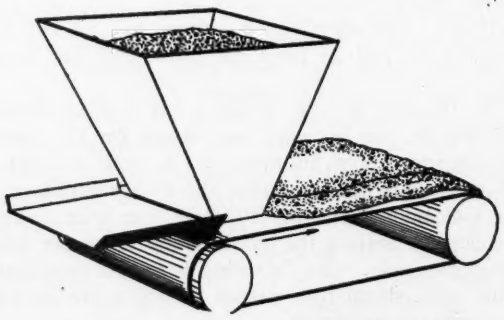
No overhead coal bunker or other coal-handling equipment was installed so that ordinarily the coal would have to be wheeled out to the front of the boilers in wheelbarrows and then shoveled into the stoker hoppers. In order to avoid this double handling of the coal, the chief engineer, W. C. Hahn, built the portable flight conveyor shown in the photograph.

Being of light wooden construction mounted on broad faced rollers, the conveyor can easily be swung into position by the fireman. It is of such a length and height that when the hopper end is in the coal storage room, the upper end is in position to discharge coal to the stoker hoppers.

After the conveyor has been placed in position, it is only necessary for the fireman to plug the motor cord into one of the many service outlets provided and shovel coal into the conveyor hopper. The only attention required is to shift the position of the upper end occasionally in order to get proper distribution across the width of the stoker. Ashes are elevated from the ash tunnel to an overhead ash bunker by the bucket elevator visible in the photograph at the back of the boiler room.

Simple Coal Sampler Utilized

COAL SAMPLING is an important part of the coal or input measurements of boiler tests and the accuracy of the test can be no better than the accuracy of the sample. To obtain true samples, it is necessary to take a complete section out of some point in the coal stream at regular intervals. The individual increments should also be of approximately equal weight. After considerable study this was accomplished in a simple manner,

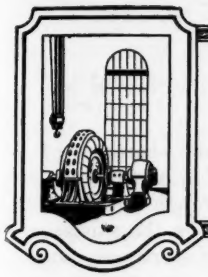


SCHEME FOR OBTAINING COAL SAMPLE FROM BELT

at the Charles R. Huntley Station and described in some detail in a paper by H. M. Cushing and R. P. Moore presented before the Fuels Division of the A. S. M. E. at St. Louis.

The arrangement and construction of the apparatus is shown in the illustration. A piece of galvanized steel was cut the proper size and two edges bent up at an angle such that it would pass under the chute which delivers the coal onto the belt of the scale. The front and back plates of the scale casing were removed and at 10-min. intervals on short tests and 15-min. intervals on long tests the sampler was passed under the feed chute and permitted to travel on top of the belt with the coal, being removed by the test man at the discharge end. The sides of the sampler, being bent up as noted above, permitted no spilling there, although there was, of necessity, some spilling at both ends. The possible error that this might produce was eliminated by providing a specially shaped piece of galvanized steel which would cut off the coal under the sloping ends of the sample for discard. A total of about 1600 lb. of coal is thus collecting for a gross sample.

This is reduced to less than ¼-in. size by passing it through a sampling mill. No advantage is taken of the mill split but both the sample and discard are saved and the whole quartered down to 20 to 30-lb. laboratory samples without further crushing.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

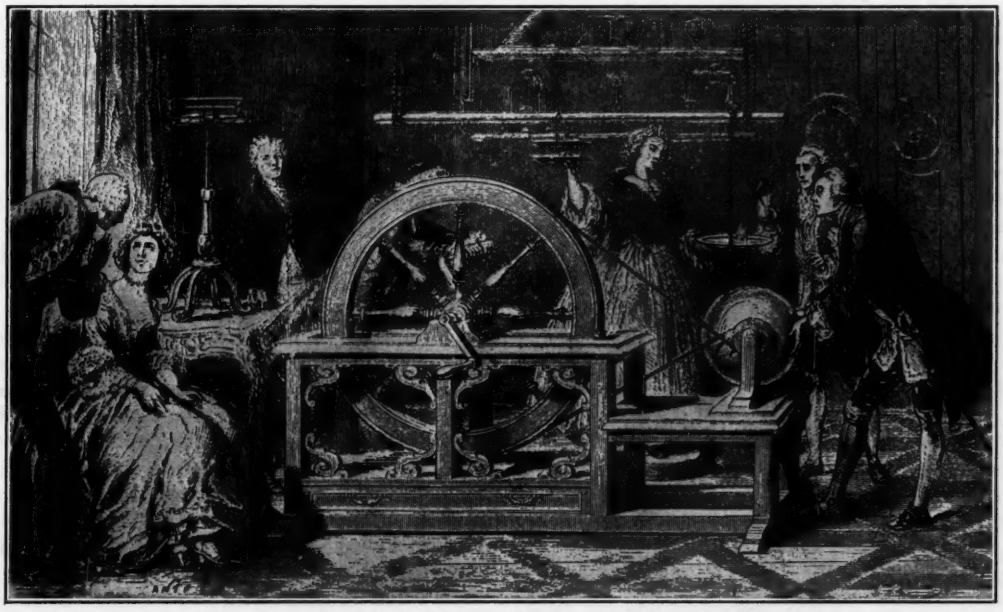
Electricity---What It Is and How It Acts

PART I. HISTORICAL CONSIDERATIONS REGARDING THE ATOMIC THEORY OF ELECTRICITY FROM THALES TO MODERN TIMES

IT IS, PERHAPS, a natural human trait that those most intimately concerned with the everyday operation of electrical equipment should least concern themselves with speculations upon the fundamental concepts on which the art rests. In a busy world, with many interests competing for every one of the 24 hr. in a day, we are likely to take these things for granted and let matters go at that. A motor operates efficiently and does its work well—why worry about the reasons for its running?

This view of the matter, while it may be perfectly satisfactory to some, to the majority, in fact, is not conducive to the continuous advancement of the art and it is well that since the beginning of history there have always been curious individuals who were forever trying to find out just what "it was all about." Such a man was Thales of Miletus, who lived some 600 yr. B. C. and who first noticed that the rubbing of amber would induce in it a new and remarkable state now known as electrification.

This Thales was something more than a keen observer, however; he was also something of a philosopher and it is perhaps more than a mere coincidence that he, who first noticed the phenomenon of electrification, also first gave expression to the conviction that there must be some great unifying principle which links together all phenomena and is capable of making them rationally intelligible; that behind all the apparent variety and change of things there is some primordial element, out of which all things are made and the search for which must be the ultimate aim of all natural science.



AN EARLY ELECTRICAL MACHINE—OTTO VON GUERICKE, 1650
A ball of sulphur was rotated, electricity being generated when it was rubbed with the hand.

Whether Thales ever suspected that the unifying principle he believed in lay in the curious phenomena he had discovered is not known; probably he didn't, but that he even thought about it is everlastingly to his credit. For it is because men like Thales and Democritus were curious and thought about the mysteries of nature that we, today, are able to enjoy the countless benefits which our knowledge of science has made possible. To those men we owe all that science has given us.

Today, we know that electricity—the same electricity

that Thales wondered about—is itself the primordial element for which the old Greek scientist groped; that electricity probably is the only thing which exists in the universe and that the fundamental laws which govern the mechanism of the electron are capable of accounting for all physical, chemical and biological phenomena. The electron is the ultimate building block of matter, out of which all substances, every element that we know of, is built. In its essential ideas, however, our conception of the world as it exists in the mind of the modern physicist is perhaps little different from that held by the Greek philosophers 2000 yr. ago. The Greek philosophers of the school of Democritus (420 B. C.), Epicurus (370 B. C.) and Lucretius (Roman, 50 B. C.) held that the world is made up of atoms in incessant vibration. Today, we hold the same opinions, with this difference, however; the conception of the ancient Greeks had its roots in the realm of speculative philosophy while ours today is founded firmly upon scientific facts.

It is, of course, natural that in their quest for the unifying principle in nature men should have speculated upon the structure of matter first and electricity afterwards. Matter is obvious; universal—so much so, in fact, that it is taken for granted. We all think we know what matter is. We are so familiar with it in its various forms that we are inclined to think that it needs no explanation. Of electricity, on the other hand, we think we know less. Familiarity with electric phenomena comes into our lives much later than familiarity with matter, so that we feel electricity is a mystery compared to matter.

Similarly, our conception of energy has been very much less defined than that of matter. Energy was said to be a property of matter. A flywheel, revolving under its own inertia was said to possess energy. We could no more think of the energy existing without the flywheel than we thought electricity could exist without matter. Both of these views were held long after the establishment of the atomic structure of matter.

But as in the case of matter, which was shown to consist of atoms, first electricity was shown to have an atomic structure and now it seems that even energy itself is atomic. Furthermore, it appears that matter, the tangible stuff of which everything is made, is nothing more than a certain form of energy—that the two (matter and energy) are equivalent and that, just as there is an equivalent amount of mechanical energy for a certain amount of heat, so there is an equivalent amount of energy for a definite amount of matter. Just as 42,000,000 ergs of energy equal one calorie of heat, so one gram of matter may disappear as such, giving rise to (9×10^{20}) *900 million, million, million* ergs of energy.

In this concept of energy-matter, it may seem that electricity is left out of the picture, but this is not correct. In speaking of matter, we unconsciously think of matter in the aggregate, i.e., as we are aware of it through our senses, not as the physicist thinks of it, as a group of atoms, each built up of component electrical charges. The electron, the ultimate particle of electricity, therefore, is also the ultimate particle of matter.

Before we begin a detailed discussion of the electron and the part it plays in electrical phenomena, it will be interesting to trace briefly the historical facts surrounding the conception of the electron and what circumstances led to its discovery.

First Suggestion of the Atomic Nature of Electricity

The first suggestion of the atomic character of the electric charge came from observation of the laws governing the passage of electricity through solutions. Before that it seems Franklin believed in the existence of an electrical particle or atom, but it is scarcely possible that he dreamed it would be possible, ever, to isolate and study by itself one of the ultimate particles of the "electrical fluid." The atomic theory of electricity was to him what the atomic theory of matter was to Democritus, a pure speculation.

In 1833, however, Michael Faraday, in experimenting with the passage of electricity through solutions, found that the passage of a given quantity of electricity through a solution containing a compound of hydrogen would always cause the appearance at the negative terminal of the same amount of hydrogen gas, irrespective of the kind of hydrogen compound which had been dissolved and irrespective also of the strength of the solution. A little thing in itself, yet how stupendous was its ultimate effect. For who, privileged to observe this young physicist in his laboratory, would have dared to predict that in the production of this bit of gas around an electrode lay a clue to one of the major mysteries in nature? Even Faraday, himself, could not have foretold that. Yet he pursued his researches. He found also that the quantity of electricity required to cause the appearance of one gram of hydrogen would always deposit, from a solution containing silver, exactly 107.1 grams of silver.

Now this was of extraordinary interest because the weight of the silver atom was known to be just exactly 107.1 times as heavy as the weight of the hydrogen atom and it meant that the hydrogen atom and the silver atom are associated in the solution with exactly the same quantity of electricity. Further experiments along this line soon made it clear that all atoms which are univalent in chemistry, that is, those which combine with one atom of hydrogen, carry precisely the same quantity of electricity; and all atoms which are bivalent, that is, those which combine with two atoms of hydrogen, carry twice this amount. In other words, it seemed as if the electricity could only be carried through the solution in certain definite blocks. These facts gave strong support to the atomic theory of electricity.

Striking as these discoveries were, they did not serve to establish the atomic nature of electricity. They were made at a time when attention began to be directed strongly away from the conception of electricity as a substance of any kind. Electricity had become to be thought of in terms of stresses or strains in the ether which surrounded the electrified body and from 1840 to about 1900 this conception was prevalent.

During this time the physicist was in a peculiar position, for when he was thinking of the passage of electricity through a solution, he thought of it in terms of specks or particles, each atom carrying an exact multiple of a unit electrical atom, while, when he was considering the passage of a current through a metallic conductor, he gave up the atomic idea and tried to

picture a continuous fluid passing through the wire. He recognized two distinct types of electrical conduction, electrolytic conduction and metallic conduction. In the meantime, however, great advances were made in our knowledge of the behavior and effects of the electric current. The self-exciting dynamo was invented and absolute quantitative measurement laid the foundations for modern electrical engineering.

Notwithstanding the remarkable development in practical electrical engineering, at the beginning of the decade before 1900, physics and chemistry found itself in a somewhat lifeless state. True, there had been many refinements—new elements had been discovered, the electromagnetic theory of light had been enunciated by Maxwell and experimentally proved by Hertz; but in the main, there was a prevailing belief that all that was worth while had been done. Little more was known about the absolute nature of electricity than was known in Franklin's time. In the face of all attempts to learn something about it, it remained the baffling mystery it had always been.

Even at that time, however, there were in our college laboratories curious, twisted tubes of glass which, when excited by high voltage, would glow with beautiful iridescence. They were little more than curious playthings and of no earthly use. It was realized that something curious was going on inside these tubes but few realized that they contained the embryo of the most amazing discoveries of the next quarter of a century, and that they would raise the atomic theory of matter and electricity from a vague speculation with hardly a hope of experimental realization to a position of surety and fact. For it was in these Geissler tubes that the first discharges of electricity through gases were observed and where, for the first time electricity was observed *apart from matter.*

Crookes' Experiments

It was Sir Wm. Crookes, who, in examining such discharges in bulbs, exhausted to a high degree by a new air pump he had made, first observed the so-called cathode ray streaming away from the negative electrode. Since there was very little air or gas in the tube, he came to the conclusion that this ray consisted of minute negatively charged particles projected across the bulb. He showed that they possessed the properties to be expected from such a stream for, on the one hand, they would heat bodies on which they fell, and on the other hand, they were deflected by a magnetic field.

These experiments at once opened up vast opportunities for research and discovery for here apparently was a fourth state of matter. The atomic theory of electricity, which had so long lain dormant, as it were, again came to the front. Of course, the proponents of the ether-strain hypothesis held that the cathode ray consisted of an electromagnetic wave of some sort, similar to light, but the experimental evidence was too strongly in favor of the negative-particle theory for the wave theory long to persist. Hertz showed that these rays could pass through thin sheets of metal and Lenard took advantage of this to coax them outside of the bulb and display their effects in the air outside.

Gradually the evidence for the atomic theory of electricity gained weight. True, the advocates of this theory had never relinquished it; in fact, in a paper read before the British Association at Belfast in 1874, G. Johnstone Stoney not only stated clearly the atomic theory of electricity, but actually went so far as to estimate the value of the unit electrical charge, i.e., the value of the smallest electric charge that is able to exist. Curiously enough, the value he obtained was about as reliable as any which had been found until within quite recent years. And it was this same Dr. Stoney who in 1891 first suggested the name "electron" for the natural unit of electricity.

Discovery of the X-Ray

Until the experiments of Crookes and for some time afterward, ideas as to how electricity is conducted through gases were vague. Some were inclined to attribute it all to dust particles. The real explanation of gas conduction was not found until after the discovery of X-ray in 1895. The convincing experiments were made by J. J. Thomson at the Cavendish Laboratory. The whole thing, in fact, grew obviously and simply out of the fact that X-rays and, a year or two later, radium rays, were found to render a gas conducting. The result was that gas conduction was shown to be due to charged particles, produced in the gas by X-rays, and that these charged particles, evidently of both plus and minus signs, disappeared by recombination when the X-rays were removed. Apparently the X-ray did something to the atoms of gas which made "ions" or "travelers" of them. The term "ion" was used first by Faraday in his explanation of conduction through liquids. So the conduction of electricity through gases was evidently electrolytic in nature.

Thomson's work in the ionization of gases by means of X-rays lent great impetus to the work of determining the ultimate electrical charge. Up to that time the only type of ionization that was known was that observed in solution and here the compound molecule such as sodium chloride (NaCl) always split up spontaneously into a positively charged sodium ion and a negatively charged chlorine ion. But in the ionization produced in gases by X-rays, something of an entirely different character took place, for it was observable in monatomic gases, that is, gases whose atoms do not combine with groups of two or more to form molecules. Plainly, the neutral atom of even such inert gases as nitrogen possessed minute electrical charges as constituents. In other words the atom, instead of being the ultimate indivisible unit we had thought it to be, was evidently a complex structure. *With this discovery, the atom as an ultimate, indivisible thing was gone, and the era of the study of the constituents of the atom began.*

By this time the conception of the electron, as simply a definite elementary quantity of electricity, had become quite definite, although little or nothing was known as to its mass, its charge or its relation to the atom as a whole. These questions at once began to interest the physicists and they began diligently to seek the answers.

The Discovery of the Electron

Here J. J. Thomson's extraordinary insight into the problem began at once to bear fruit, and during the next few years there issued from the Cavendish Laboratory a wealth of most remarkable data. The first partial answer to the question regarding the mass of the electron

came from a comparison of the relation of the charge to the mass of the hydrogen ion in solutions to that of the same relation in the negative ion in the gases of highly exhausted tubes. Thomson and Wiechert, independently, in 1897 showed that the relation of the charge to the mass for the negative ion in exhausted tubes was about 1800 times the value of the ratio between the charge and the mass for the hydrogen ion in solutions. Since the total quantity of electricity involved was about equal in gases and the solutions, the only possible conclusion to be drawn from this was that the negative ion appearing in electrical discharges in exhausted tubes had a mass only 1/1800 the mass of the hydrogen atom—the lightest of all atoms!

Next, they turned their attention to the positive ion. What was its mass? What was its relation to the negative ion? Alhough the researches on the positive ion were first carried out by Wien, the most successful work on this problem was done by Thomson. The result was that it was proved quite conclusively that the ratio of the charge to the mass of the positive ion in gases was never larger than it is for the hydrogen ion in electrolysis and that it varied with the different sorts of residual gases just as it is found to do in electrolysis.

With the results of these investigations on the mass of the ions available the physicist, in the few years before 1900 was able to form the first mental picture of the neutral atom and understood for the first time the process of ionization. The atom, it appeared, consisted of a positive ion of practically the same mass as the atom itself, with which was associated one or more negative ions each having only 1/1800 the mass of the lightest of all atoms—the hydrogen atom. Furthermore, the mass of the negative ion was always the same, regardless of how produced or in what gas. And the process of ionization appeared to be nothing more than the detachment from a neutral atom of one or more negative ions, or corpuscles as Thomson called them.

All of this happened before 1900. Since that time great advances have been made in our quantitative knowledge of the elements involved in the structure of the atom, but the conclusions reached in regard to the nature of electricity and its relation to matter have not been modified in their essentials.

With the existence of the electron fairly well established attempts to determine its charge and mass went forward rapidly. Numerous investigators attacked the problem, each succeeding measurement being made with increasing skill and understanding. They reached their high water mark in the brilliant oil drop experiments of Millikan at the University of Chicago. Millikan observed the behavior of a single drop of oil floating in dust free air between electrically charged plates. As the droplet became charged by attaching to itself or losing an electron, its electric charge increased or decreased and it was drawn to one or the other of the plates. By carefully noting the charge applied to the plates by a high voltage battery, and measuring the speed of the droplet under various conditions, Millikan was able to calculate with great accuracy the amount of charge due to a single electron.

These experiments of Millikan are of tremendous interest and will be described in greater detail in another article of this series. It will be helpful toward a better understanding of the experiment to first learn something of the part played by the electron in ordinary electrical phenomena. This will be discussed in the next article.

Commutation Control of Booster Converters

A General Discussion of Some of the Older Types of Control Together with a Description of Systems Embodying Latest Practice. By L. A. Vaupre*

FOR SECURING a wide range in direct current voltage when connected to a fixed value of alternating current voltage supply, the booster type of converter has superseded all other types. Other methods for obtaining this control are field control through reactance, and variation of field form by the obsolete split pole type of construction. For extreme voltage variation outside of the scope of any of the above named methods, the alternating current supply can be varied by means of either a regulator or a change in the transformer taps.

In construction, the booster converter is the same as a standard converter to which a synchronous alternating current generator has been added. In general, on all of the larger size machines, the booster is of the revolving armature type. On these units, the booster is placed between the converter armature and the collector rings, as may be noted in Fig. 2.

On the smaller size of units, the booster is sometimes of the revolving field type, in which case it is located outside of the main bearing with the armature leads carried to the collector rings, as in Fig. 1. The booster field poles are located so that a given booster field excitation produces equal "buck or boost" in the converter no load voltage. Figure 3 shows a cross section of a synchronous booster converter and Fig. 4 shows the connections of the converter and booster armature windings.

The booster converter undergoes armature reactions, affecting commutation, which is comparatively nonexistent in the combination voltage regulator and straight converter. This is due to the fact that the current distribution in the armature of a straight converter running at low voltage is less favorable to cool operation than the booster converter. When a booster converter is running under buck conditions, the small component of torque supplied by the booster element helps to reduce the phase* angle of displacement to a minimum.

By varying the excitation of the booster, its voltage may be added to or subtracted from the line voltage supplying the armature of the converter. At no load, the armature reaction of the converter is very small, as only the current used in supplying the no load losses

*Power Engineering Dept., Westinghouse Electric & Mfg. Co.

*Armature lag behind field magneto-motive force as in synchronous generator.

together with slight stray losses are present in the armature. Wattless current produces a change in the commutating zone, which is of importance only when the machine is carrying an appreciable amount of direct current load. (For a mathematical treatise on the armature reaction of the straight converter, the paper of T. T. Hambleton and L. V. Bewley, proceedings of February 7-11, 1927, convention, A. I. E. E., may be consulted; for a non-mathematical treatment, B. G. Lamme's paper, "Commutating Poles on Rotaries," gives useful information.)

Contrary to some older beliefs, the normal reaction in the commutating zone of the rotary converter is not zero. Due to the fact that the alternating current within the armature windings opposes the direct current, the armature reaction is reduced to a much lower value than would be obtained if the machine were operating as a direct current generator of same output; however, the distribution of magneto-motive force due to the alternating current is different from that of the direct current and varies according to position of the phase bands within the converter. This resultant varies at six times line frequency. The actual flux variation is probably much less due to the damper winding, the important fact being that the average magneto-motive force in the commutating zone of the normally operating six-phase converter is about 15 per cent that of the same machine at a direct current generator. The commutating pole of the straight converter is therefore designed to take care of this 15 per cent armature reaction plus an additional amount of ampere turns necessary for the magneto-motive force required to produce good commutation. The magneto-motive force for these purposes is acquired from a winding carrying line current or a portion of line current. Since the current through these windings cannot be finally adjusted to the correct value, the commutating pole air gap and the shape of the gap is calculated to suit a given commutating pole magneto-motive force. Commutating poles having a very large gap and relatively high magneto-motive force windings are called "high reluctance" poles and are used on machines subject to rapid variations in load.

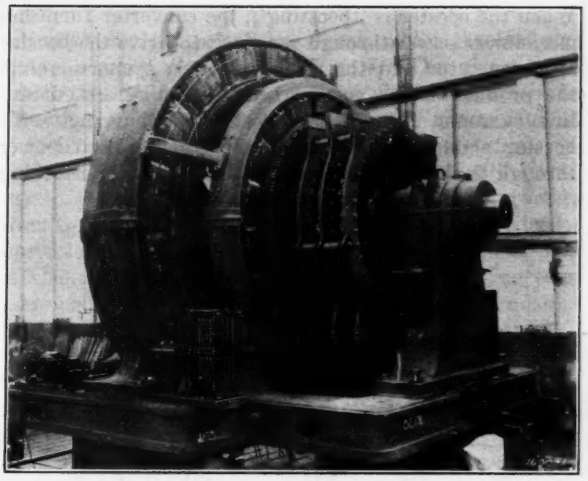


FIG. 2. 17,000-AMP., 270-V., 6-PHASE, 25-CYCLE, 167-R.P.M. BOOSTER CONVERTER, SHOWING TORQUE MOTOR AND MOTOR-OPERATED BRUSH-LIFTING DEVICE

Due to torque on the shaft representing input or output of mechanical power, the current flowing in the converter armature is changed in such a manner that the armature reaction in the commutating zone is increased or decreased proportionally. Assuming a converter to be carrying normal load on the direct current end, as stated above, the machine will have a normal reaction of 15 per cent. Without changing other conditions, a mechanical load applied to the shaft amounting to 15 per cent of the normal electrical output will reduce the average armature reaction to zero. Conversely, a 15 per cent input of mechanical power will increase the reaction from 15 per cent to 30 per cent. This is similar to what happens in the case of the booster converter.

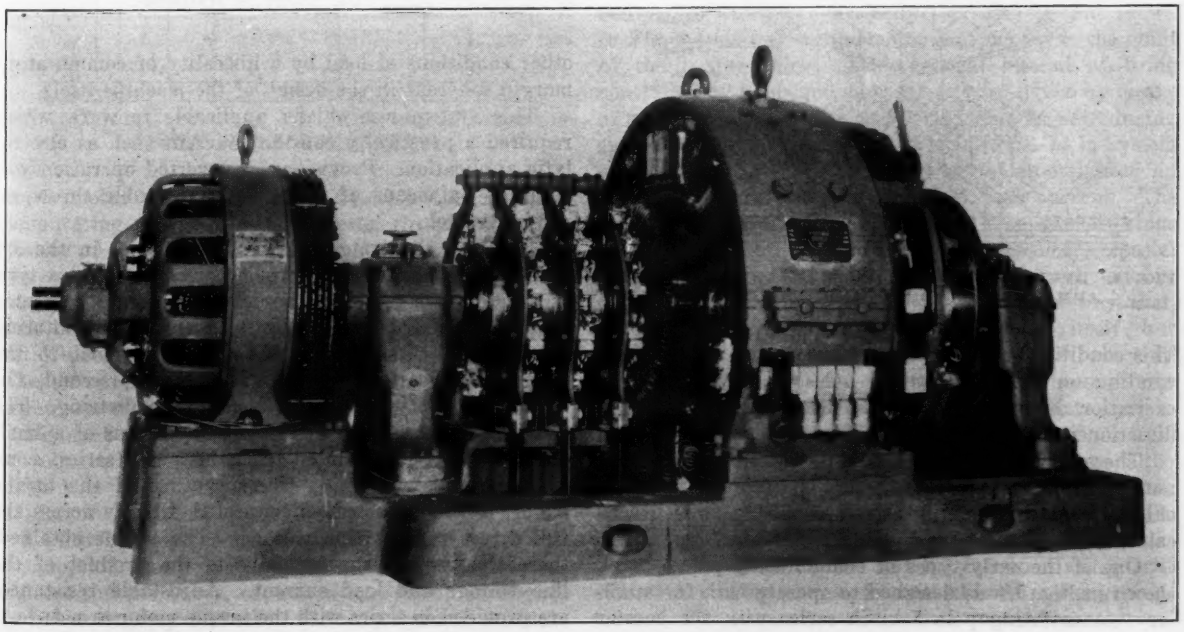


FIG. 1. 2000-AMP., 250-V., 60-CYCLE, 6-PHASE, 1200-R.P.M. SYNCHRONOUS BOOSTER CONVERTER

When the booster is "boosting", the converter furnishes mechanical power through the shaft to drive the booster as a generator and the shaft torque is proportional to the product of the voltage boosted and direct current line current. When the booster is "bucking," the booster acts as a motor delivering mechanical power through the shaft opposing the generator action taking

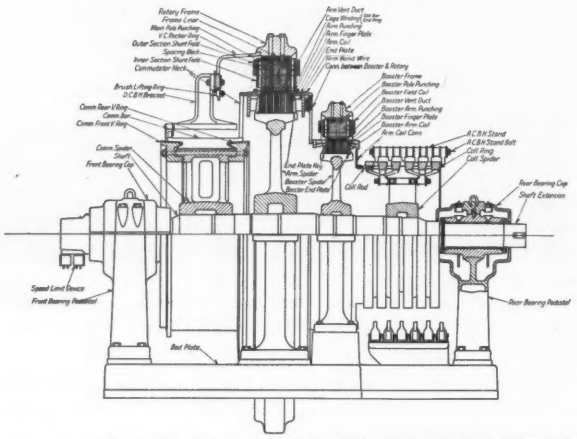


FIG. 3. CROSS SECTION OF THE SYNCHRONOUS BOOSTER CONVERTER

place in the converter armature and the shaft torque is again proportional to the product of the voltage bucked and the direct current line current. In other words, the torque on the shaft between booster and converter armature is proportional to the load on the booster, consequently the armature reaction component due to the booster is proportional to the booster load.

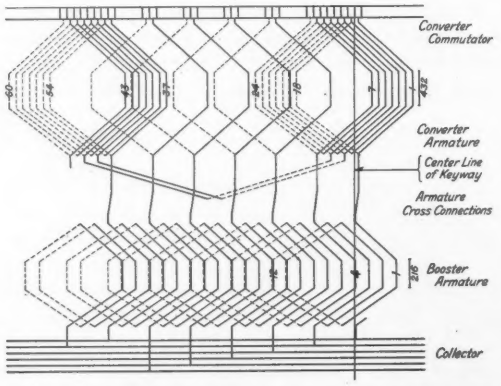


FIG. 4. DEVELOPMENT OF BOOSTER AND CONVERTER ARMATURE WINDINGS AND CONNECTIONS

This condition makes it necessary to place an auxiliary winding on the commutating pole which will produce excitation in proportion to the booster load and in a direction correct for the conditions of buck or boost.

These conditions cannot be fulfilled exactly and are not absolutely necessary to plain operation of the machine but should be approached as nearly as is practicable, and economically possible for the best operation.

One of the early types of commutating pole control, shown in Fig. 5, was designed to operate with the auxiliary commutating pole field in series with the booster field. The auxiliary winding was accordingly excited in proportion to the buck or boost voltage. This meant that the commutating pole would be excited whenever the voltage was bucked or boosted, even though no direct current load with corresponding armature reaction existed. It was necessary, therefore, to install a relay system which would short circuit the auxiliary commutating pole winding and insert a compensating resistance "A" during light and no load conditions. At some pre-determined value, say one-third load, the relay operated to cut out the resistance and insert the auxiliary commutating pole winding. This immediately excited the commutating pole with whatever current happened to be in the booster field. The relay was operated by the drop across the series commutating pole field. This system was adjusted so that the auxiliary commutating pole winding exactly compensated armature reaction due to buck or boost in voltage at the operating condition maintained. The fact that this system did not give proper auxiliary ampere turns at any but the one operating condition was partly compensated for during

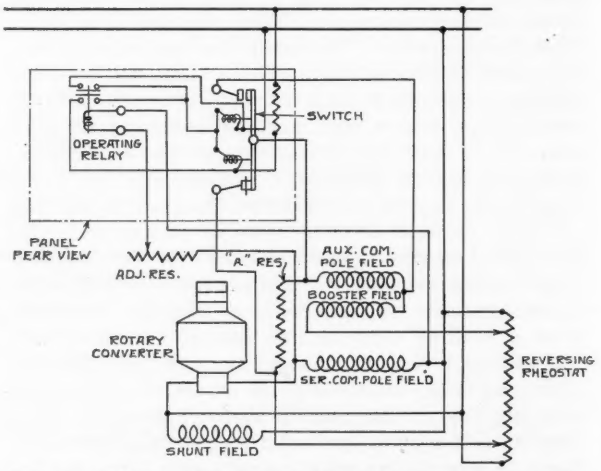


FIG. 5. AN OLDER TYPE OF COMMUTATING POLE CONTROL FOR BOOSTER MACHINE

other conditions of load by a liberality of commutating margin inherent in the design of the machine itself.

This system was chiefly applicable to work which required a practically constant current such as electrolytic application. Provision for inverted operation was obtained by means of a double pole double throw reversing switch.

Figure 6 illustrates a later development in the art of control on commutating pole converters. This type of torque motor control differs from the older contactor type mentioned above as follows: first, the commutating pole auxiliary field excitation is proportional to the product of booster voltage and amperes; second, the torque motor itself, with its rheostat and wiring. The field of the torque motor is excited by means of a small amount of current shunted from the main (series) commutating pole winding. The armature of the torque motor, it will be noted, is connected directly across the full direct current line voltage. The torque obtained, therefore, varies proportionally to the product of the line voltage and load current. Adjustable resistances are provided in series with the torque motor armature to take care of any final calibrations required. This ar-

rangement causes the motor to produce torque under the condition of full load, regardless of the condition of the booster. The torque produced is opposed by a helical spring so that at full load current the rheostat operated by the torque motor is almost cut out, as shown by the torque motor arm in Fig. 6. No current will be flowing in the auxiliary commutating pole winding, however, unless there is some excitation in the booster field circuit. The booster field rheostat and the auxiliary commutating field rheostat are mechanically connected so that an application of voltage to the booster field will require an application of corresponding voltage to the auxiliary commutating pole field circuit. The total result is: the currents in the auxiliary commutating field and booster field vary proportionally as the direct current voltage and load current vary. Disregarding refinements for the present, the above control results in a commutating pole magneto-motive force which compensates for simple armature reaction in proportion to line current, and compensates for main shaft torque in proportion to the product of booster voltage and load current.

In order that the auxiliary commutating field and booster field be excited by the right ratio of currents and also to give some order of flexibility to the arrangement, adjusting resistances are incorporated in the rheostats. As there is considerable difference in the direct current voltage between full buck and full boost, which condition would materially affect the current in the auxiliary commutating pole winding, provision is made for an additional internal resistance not shown in the

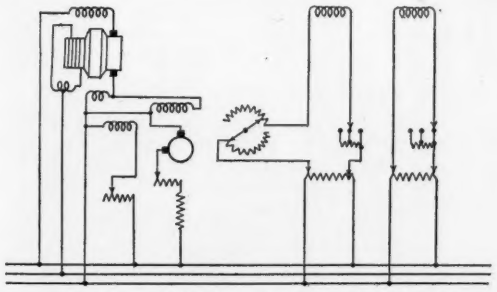


FIG. 6. WIRING DIAGRAM OF SUPERSEDED TYPE OF BOOSTER CONVERTER CONTROL

torque motor control diagrams, to keep the auxiliary commutating pole field winding properly excited. The polarity of the booster field winding is so arranged that this resistance is all in the auxiliary commutating field circuit at maximum boost and all out of circuit at maximum buck. The total value of this resistance is such that it produces the effect of a constant direct current voltage impressed upon the auxiliary commutating field throughout all operations.

Figure 6 does not provide for inverted operation of the converter without the installation of a double pole double throw reversing switch in the commutating pole auxiliary field circuit.

Figure 7 shows the latest type of control which has been applied, the only fundamental difference between this and the one above, explained and shown in Fig. 6, lies in the two way feature of the torque motor rheostat. The torque motor for this rheostat is allowed 360 deg. range, i.e., 180 deg. each side of neutral; the spring is so adjusted that at no load the torque motor rheostat arm lies at neutral, as shown in Fig. 7. The direction in which the torque motor arm moves will depend upon the direction of current exciting the torque motor field, so that in case of inverted operation during a line disturbance, the auxiliary commutating field will be reversed automatically when the torque motor arm reverses over to the opposite side of the rheostat. The time of operation of the torque motor for such changes in load is about one-third of a second—a length of time commensurate with the usual system disturbances, and flux changes in the commutating pole.

The "two-way" type of torque motor control (Fig. 7) requires an available voltage of either polarity. This is acquired by utilizing the neutral of a three-wire system as the datum point and varying the other end of the auxiliary commutating field circuit over a resistance

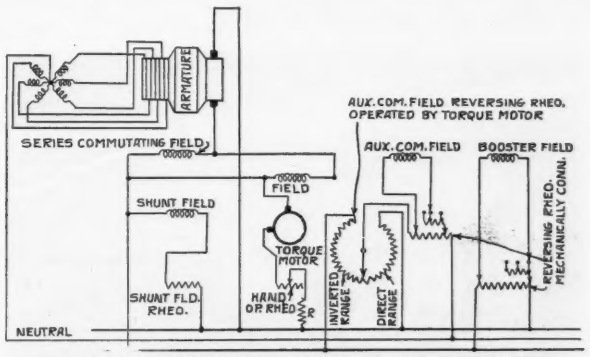


FIG. 7. STANDARD BOOSTER CONVERTER TORQUE MOTOR CONTROL

which is connected across the total line voltage. These connections are clearly shown in Fig. 7. If the system is not a three-wire system, the neutral is available from the transformers.

There is another system in use on modern booster converters which is practically the same as that shown in Fig. 6 (one-way torque-motor control) up to the point of the torque-motor. The rheostat, instead of being controlled by a torque motor directly, is driven by means of a small direct current motor through a speed-reducing system. The driving motor is controlled by a system of contactors actuated by a relay which balances an alternating current potential against load current. The alternating current potential is taken from the slip rings of the converter and is varied by means of a special rheostat controlled by the same small direct current motor. This special rheostat acts in such a way that, through the relay, it opposes progression of itself; but the higher the load current the higher is the balancing point of the relay and, as a result, the rheostat arm (corresponding to the torque motor rheostat arm in Fig. 4) progresses according to the load current. This is practically the same as the torque motor action of the torque motor control system, wherein the torque motor operates in one direction only. This contactor system can be made to take care of inverted operation automatically by exciting the auxiliary commutating field control circuit by means of a special little motor generator set. The generator of this little motor-generator set should be excited by a portion of line current so that in case of inverted operation the generator voltage will

reverse; consequently the auxiliary commutating winding will also reverse.

The contactor control mentioned above is, in general, slower to arrive at equilibrium after a change in load which makes it more difficult to apply to converters which are subjected to rapidly varying loads. The large number of contacts of the contactor system presents an additional maintenance problem.

Insofar as demands have been made and met upon the development of this type of power machinery, the corresponding problem in control has also been brought up to a suitable level by experiment and research. Extra refinements and development pertaining to commutating pole auxiliary field control on synchronous converters will no doubt be required as operating conditions become more exacting on this particular line of apparatus.

Travels With a Technical Editor

HARRY, THE BUTTERMILK ADDICT, FINDS MUCH OF INTEREST IN HIS TRAVELS TO VARIOUS POWER PLANTS

"WELL, OLD TIMER, we're out of breath but we're here and that is something to be thankful for; if we missed this train, we wouldn't get another for Phili before tomorrow morning."

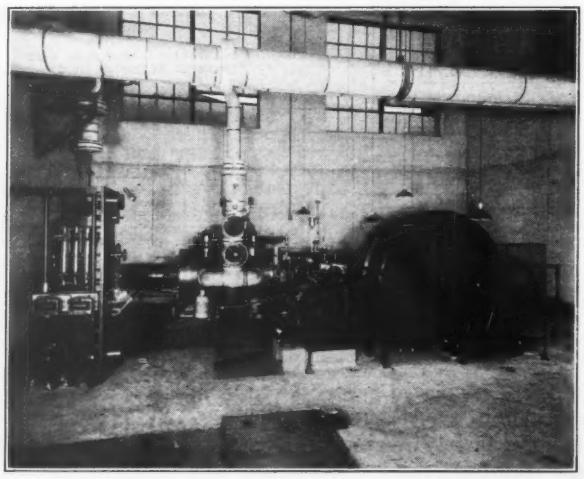


FIG. 1. THE NEW UNIFLOW ENGINE AT THE ERIE COUNTY MILK ASSOCIATION

"Whew——well, what of it?" puffed my breathless companion. "Is this the way you fool editors always travel? What difference would it make if we spent another night in Erie? I'd just as soon have gone back to that Milk plant tonight and had some more of that buttermilk."

"Buttermilk! my gosh, what a taste for a 60-yr.-old throttle twister. Here, calm yourself, old man; have a cigar; you'll be natural again in a minute. The exercise did you good. Let's go up to the smoker."

Once in the smoker, with a good cigar to sooth him, Harry, which was my companion's name, regained his breath and his good nature. We were just pulling out of Erie, Pa., on the 7:20 "Pennsylvania," bound for Philadelphia. We had spent the afternoon at the power plant of the Erie County Milk Association where I gathered data for an article, and Harry insisted on swapping experiences with the chief so long that we almost missed our train. Hence the excitement.

"Well, Mr. Editor," said Harry after he had been puffing furiously for several minutes, "this plant we saw this afternoon only proves my point, that the central station can't compete with a good private plant. There they were, before the engine was put in, buying 27,000 kw. a month at 1¾ cents per kw-hr., yet in spite of that low rate, today, with a good uniflow engine, making their own juice, they are saving a clear $500 a month."

"Probably in this case you're right, Harry, but don't forget there was a $50 demand charge attached to the power rate and they have a very good use for low pressure steam. In another plant where the steam and electrical demands were less balanced, the savings wouldn't be as great."

"I know, I know, Mr. Editor," replied my friend, impatiently, "you're always bringing that point up but that doesn't alter the fact that, in this case, with a

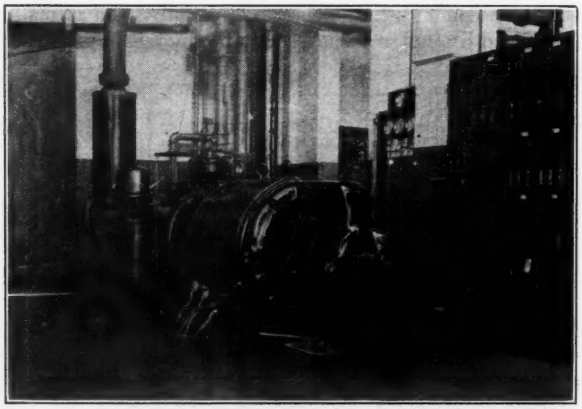


FIG. 2. ONE OF THE TURBO-GENERATORS AT THE PHILADELPHIA TAPESTRY MILLS

250-kw. uniflow engine costing $11,000, they are saving $500 a month. I'd like to see any young upstart of a power salesman——"

"There now, don't get so excited old timer—I'm not arguing with you in this case. I'll admit, Mr. Wiseman, the general manager of that Milk Association, is pretty level headed and did a wise thing in putting in that engine. If he keeps it going, before long he will be able to reduce the price of buttermilk——"

"Buttermilk! Gosh that was good stuff, wasn't it? I'd like to have some more now. By the way, Mr. Editor, do we go through Pittsburgh on this steam wagon?"

"Pittsburgh? No, not on this train. We cut across to Williamsport where we connect with the branch of the Pennsy that goes to Elmira, and then we go down to Harrisburg where we hit the main line."

"Williamsport? Well by gosh, I'd like to stop off

and see my old friend Jack Randolph. Jack and I used to run the old 700-hp. Harris Corliss at the Bausch & Lomb plant up in Rochester 25 years ago. I tell you, Mr. Editor, that was some engine—26-in. cylinders, 48-in. stroke, with an 18-ft. hand wheel making 60 revolutions. Ran as slick as a whistle. Jack and I took more care of her than——"

"Yes, I know; spent 6 days a week and Sundays running around the outfit with an oil swab to keep her from squeaking and then boasted about her running like a watch. You fellows certainly liked work a whole lot more than I do. I'm perfectly satisfied to hook a pressure lubrication system up to a turbine and let her spin."

* * * * *

At Philadelphia the next day, our program called for a trip to the plant of the Philadelphia Tapestry Mills. This is an old plant but is of interest because it shows that care and attention to details will produce dividends in terms of increased efficiency and more reliable operation. The plant consists of two units, an old section consisting of a boiler house with turbine room and a new unit consisting of a boiler house with strictly up-to-date equipment. The new boiler house is operated in conjunction with the old plant and, during the summer, is used exclusively, since it takes less help to operate it. In fact, one man attends to the entire 1500-hp. plant without difficulty.

"Meet my friend, Harry Winters," said I to Mr. Brennan, the chief engineer of the plant, after having made the purpose of our visit known.

"Glad to meet you, Mr. Winters," replied Brennan. "Guess you don't mind shaking an oily hand do you?"

"Not if it's engine oil, I don't," boomed Harry; "I may be on the shelf myself, but I'm always glad to meet one of the boys. D—n nice outfit you got here, Mr. Brennan; how big is it?"

"Well, altogether we've got about 2100 b-hp., counting the five old boilers. There are two turbines, that one behind you (Fig. 2) which is a 300-kw. unit and another 750-kw. machine in the next room. We make all our own juice here at 220 v. but most of our steam is used in the mill for process purposes."

"You see, Mr. Editor," remarked Harry with a grin, "this is another case which proves my point. Wherever there is use for the exhaust steam from the engines or turbines, it pays to make your own power."

"But we don't use the exhaust from the turbines," interposed the chief engineer.

"You don't?" exclaimed Harry. "Do you run condensing?"

"Sure, Mr. Winters. Both turbines are provided with surface condensers, using city water for cooling. No cooling tower is used. We find that we need so much water in the mill that we have enough to use in the condensers before it goes into the system. In this way, we not only get the advantage of running condensing but, at the same time, reclaim the heat abstracted in the condensers."

The water supply system, in fact, proved to be one of the most interesting features at the plant. Water was stored in a 52,000-gal. tank on the roof, the level of which was automatically maintained. Water for various purposes, including boiler feed, is taken from this tank.

Another thing of interest was the connection between the two feedwater heaters in the two boiler plants. These were connected as shown in Fig. 3, so that, in summer when the old boiler plant is not used, the feedwater heater at that plant is used as a hot well. A small duplex pump takes water from the old heater and sends it to the heater in the new plant.

* * * * *

"Well, Harry," said I, on our way back to town from the plant, "suppose we have a bite to eat and run down to the University of Delaware at Newark, Del. They have been doing some new work, I understand."

"Suits me, Mr. Editor; I'm not very hungry though; let's get a sandwich at Broad Street Station and take the first train down."

But our lunch had to be postponed. Just as we got to the station, we found a train leaving in three minutes and, as the next one stopping at Newark would not leave till two hours later, we hurriedly bought our

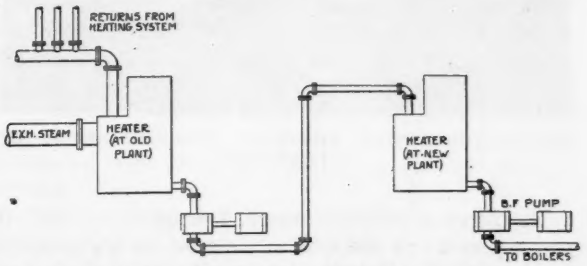


FIG. 3. METHOD OF USING OLD FEEDWATER HEATER AS A HOT WELL

tickets and got aboard. Fortunately the train carried a diner.

Arriving at Newark, Del., a little over an hour afterward, I called up Mr. McKay, the chief engineer at the University of Delaware, and when we reached the campus ten minutes later found him supervising the construction of an underground steam line.

"Glad to see you, Mr. Editor," he said; "I've been wanting to meet you because I know you will be interested in the architectural features of our power plant."

"Well, that's interesting;" I replied, "the subject of architecture in regard to power plants has concerned me quite a little and we have published some articles on the subject."

"Yes, Mr. McKay," said Harry; "He's a regular bug on that subject. Wants to make all power plants Greek Temples with Japanese sunken gardens around the coal piles."

"Don't mind this old timer, Mr. McKay," said I; "he doesn't appreciate art. At the same time, I admit the charge. I do like to see good looking plants; in fact, I have repeatedly stated that there is no earthly reason why a power plant should not be made reasonably attractive."

"I know," replied McKay, smilingly; "I've been reading those articles and it's just that point I want to argue about. Now take a look at that plant."

McKay pointed to a drab box-like structure with two common black steel stacks surmounting a gabled roof. Certainly the structure was anything but attractive; in fact, compared to the exquisite architecture of the other university buildings, it was positively ugly.

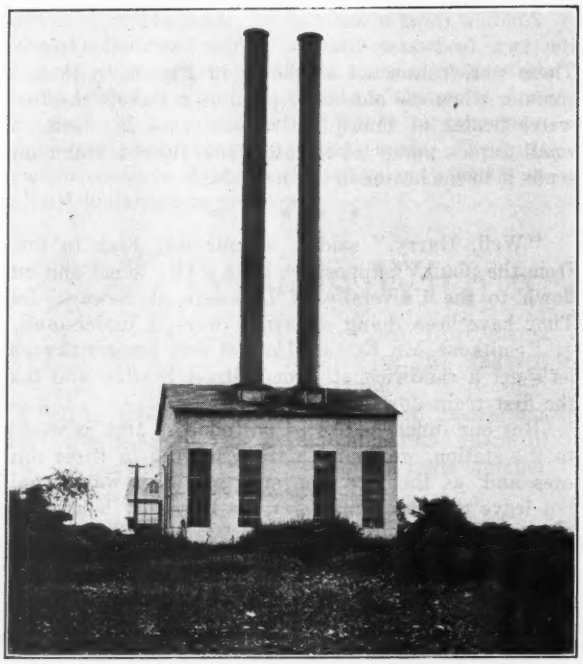


FIG. 4. THE POWER PLANT AT THE UNIVERSITY OF DELAWARE

Realizing a joke somewhere, I laughed. "Well, if you expect me to use that as material for an architectural article, I will be glad to use it as one of my horrible examples, but I'm afaid that's the only way I can use it."

"Don't expect me to justify the architecture," laughed McKay, "for I don't, but I'll explain the facts. For a long time, as our heating load constantly increased, we realized that we should have to replace our old boiler houses with new equipment. The two old boiler houses we had were in a badly run down condition and it was imperative that we build a new plant. Appropriations for such work were limited, however, and we found that, with the funds available, we could not build a plant such as would harmonize with the other buildings in the University group. What was desired was an up-to-date plant, centrally located, which could be added to.

"So we called in a consulting engineer and the proposition was made to build a boiler plant which would be modern so far as equipment was concerned, but which would be housed in a more or less temporary structure. The result, gentlemen, you see before you (Fig. 4). The building is nothing more than a sheet steel covering to protect the steam generating equipment from the weather."

Harry laughed.

"I have a sneaking idea," he said, "that those at the bottom of this affair purposely made the building unattractive so as to compel the 'powers that be' to construct a more attractive plant as soon as possible."

"How about the equipment, Mr. McKay?" I asked.

"Oh, in that respect," he answered, "only the best was selected. We bought that with a view to permanence. All that will be necessary, when the proper time comes, will be to build a new building around the present structure; when it is finished, we'll tear the old one out."

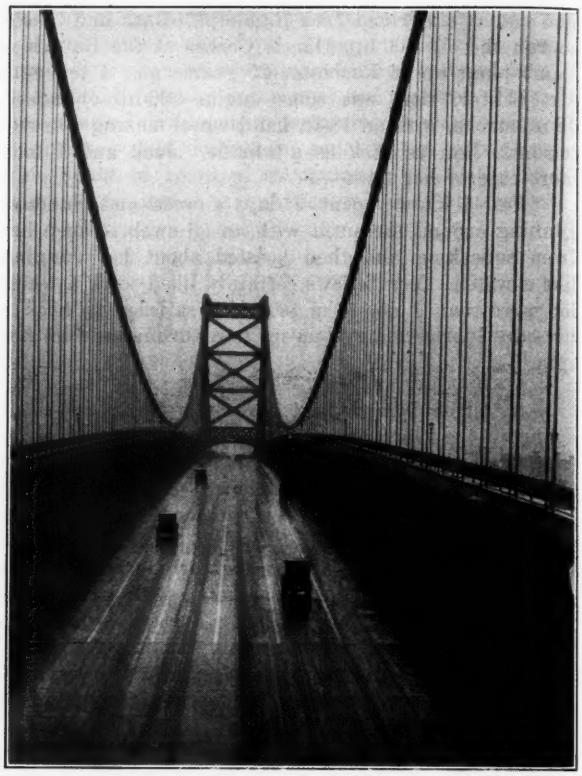


FIG. 5. "WHO HAS FAILED TO SEE THE BEAUTY IN THE MAJESTIC SWEEP OF THE DELAWARE RIVER BRIDGE?"

"The equipment itself consists of two 300-hp. modern water-tube boilers fitted with hand stokers, together with forced draft and other auxiliary equipment. This is sufficient to carry our present load and, if necessary, more capacity can be added easily.

"Ultimately, we expect to put in two additional 300-hp. units together with electric generating equipment."

* * * * *

"You know, Mr. Editor," said Harry the next day as we sat in the smoker, bound for New Hope, Pa., where we were to visit the Union Mills Paper Mfg. Co., "as I travel around with you, visiting these various power plants, I am inclined to doubt the fact that engineering is an exact science."

"Well, I don't know that it is claimed to be an exact science," said I.

"Perhaps not," said my companion, "but many regard it in that light. When I see these power plants, I try to picture in my mind what was behind each designer's mind and try to formulate a set of general principles which are common to all; but the more I see, the more am I inclined to regard much in engineering as a haphazard business, in which the personal opinion and likes and dislikes of the designer play a far greater part than exact knowledge."

"I have often been struck with the same thought," said I, "but isn't it because we are wrong in regarding engineering as a science? Isn't engineering more of an art than a science and isn't the true engineer just as much of a creative artist as a painter or a musician?

The engineer takes the materials and laws which science places at his disposal and uses them to give form to his conceptions. In doing so, he injects his personality into his work just as the artist does. A great bridge, or a power plant or a vast industrial works is just as much a work of art, in my opinion, as a symphony. True, because of the magnitude of the engineer's works and the financial outlay involved, he is less free to pursue his personal impulses; but he is a poor engineer who does not inject at least a certain amount of his own personality into his work."

"By George, I never thought of it in just that light," exclaimed my companion. "That's certainly a new way of looking at it and I'm not so sure but that you're right. I think I see the point. It is not engineering that is an exact science, but the mathematics which underlie it.

"Of course," I continued, "art is usually associated with beauty, and since beauty is something which appeals directly to our senses, it may be difficult to see the parallel between a bridge and a symphony in that respect. Yet, it may be that there is a different kind of beauty inherent in the engineer's work than in the musician's. Certainly no one with any degree of emotion at all can have failed to see the beauty in the majestic sweep of the Delaware River Bridge, or in the graceful lines of a large ocean liner.

"But here's New Hope and we must get off."

New Hope, Pa., is a pleasant sleepy little town on the Delaware River, not far from Trenton. We had seen the sign of the Union Mills Paper Mfg. Co. across the river as the train pulled into town and, as it was nearby, we walked over to the plant.

Arriving there we found that they had recently built a new boiler house, a strictly modern plant with two 216-hp. boilers with mechanical stokers. A view of this boiler house is shown in Fig. 6.

Coal is delivered by barge and placed in storage or delivered to the plant for immediate use by an electrically operated crane. It is delivered into an overhead coal bunker by a standard conveyor system from which it is withdrawn by a standard weigh larry which records the weight of each charge. Modern steam and water regulating equipment as well as suitable indicating and recording instruments are provided so that an accurate check may be kept on operation.

Harry, however, was more interested in the engine room. Here we found a 200-hp. uniflow engine driving a 600-v., a.c. generator, as well as an old turbine-generator set. The latter consisted of a 9000-r.p.m. steam turbine driving two 150-kw., a.c. generators and an exciter through a reduction gear.

This unit is used only when needed to take care of an emergency condition. It is efficient only when run at full load and, since it must run condensing, its operation does not increase the overall efficiency of the plant. Since all the exhaust steam from the prime mover can be utilized in this plant, the actual water rate of the prime mover is not highly important.

"That certainly is an old timer," said Harry, referring to this turbine. "But, why is that one generator uncoupled from the turbine and in operation? What's driving it?"

"It's running as a motor," replied the chief who was showing us around. "You see, we have a large number of induction motors in the mill, and the power factor tends to be low. So we usually run one of the generators on this turbine unit as a synchronous condenser, by operating it as a motor and over-exciting the fields. This works fine, and has enabled us to carry much more load on the engine-driven generating unit. The power factor is kept up to 90 per cent at all times."

"Do you generate all your power?" I asked.

"No, at present we buy most of it, but we intend to build a new engine room soon and then we will install sufficient generating capacity to take care of all our power requirements. By the way, did you notice our long distance boiler feed system?"

"Long distance boiler feed system," repeated Harry, "what do you mean?"

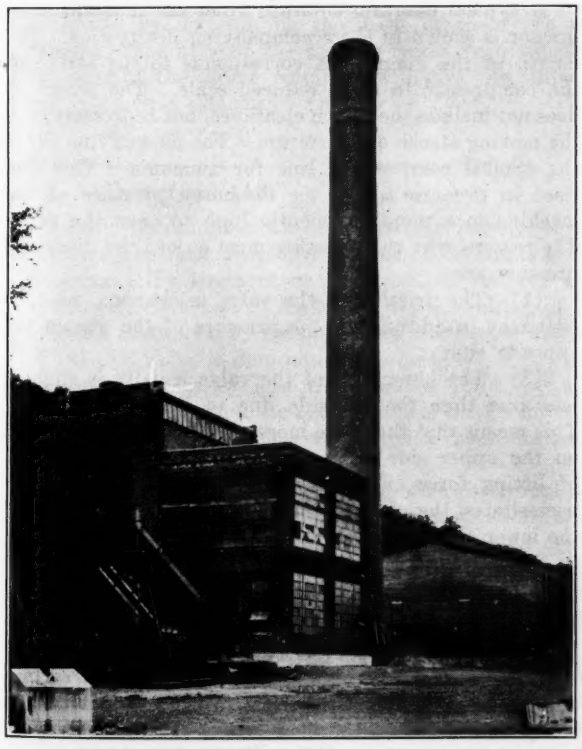


FIG. 6. THE NEW BOILER PLANT AT THE UNION MILLS PAPER MFG. CO. AT NEW HOPE, PA.

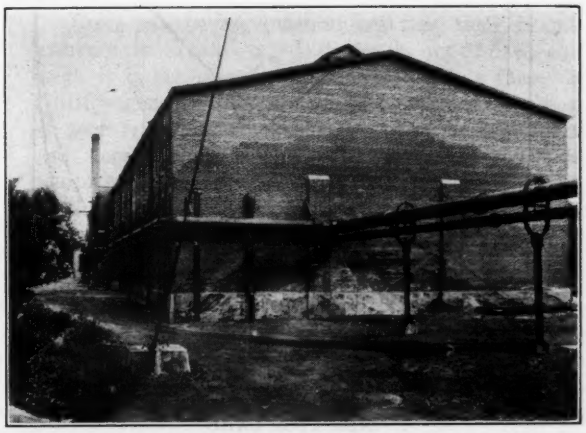


FIG. 7. LONG FEEDWATER LINE AND HIGH-PRESSURE STEAM MAIN AT NEW HOPE

"Just what I said," laughed the chief. "You see, the old boiler plant was adjacent to the engine room, while the new one is at the other end of our property. Since we had our feed pumps and feedwater located here and since all the returns from the mill and the exhaust steam from the engine are available at this point, it was decided when the new boiler plant was built to leave the feed pumps and feed heater in the old plant and pump the water to the new plant which is about 700 ft. away. So we installed the outside pipe line (Fig. 7) which you probably noticed on your way from the new boiler house. The small one is the feedwater line and the large one the high-pressure steam main."

"I see," said Harry. "It was a question of running the exhaust line or the feedwater line to the boiler house."

"Exactly, Mr. Winters," said the chief, "and we found it more satisfactory to carry the hot feedwater than the exhaust steam, since we have no trouble from condensation."

* * *

"Well, Harry," I remarked, as we were waiting for the train to carry us back to Philadelphia, "do you think you'll go to New York with me tonight to attend the A. I. E. E. convention, or do you expect to go straight home?"

"Guess I'll go to New York with you," he replied, "but don't expect me to go to the A. I. E. E. convention. Those boys are too highbrow for me. No sir, I'm going to look up my old friend, Bill Crandon, and maybe we'll hit some of the high spots on Broadway.

"Some of those buttermilk joints, I suppose?"

"Gosh! I had almost forgotten about that buttermilk. By George, when I go back I'm going to stop off at Erie and get some more of it."

Testing the Refrigerating Plant

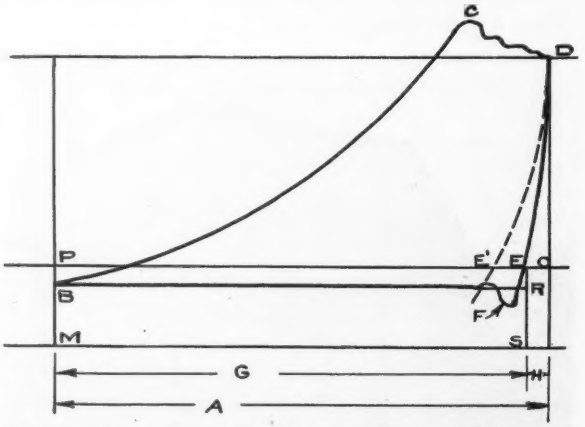
PART II. THE DETERMINATION OF OUTPUT OF THE AMMONIA COMPRESSOR BY THE INDICATOR. BY W. R. WOOLRICH*

IN TESTING a refrigeration plant, it is often inconvenient to make determinations of the compressor capacity by weighing ammonia or measuring it volumetrically. While the measurement methods of weighing, or measuring by graduated tank, is the more desirable and accurate method of determining compressor output, there are many times when an indicator analysis of the output is sufficiently accurate to give the information desired.

THE INDICATOR

Before dependence can be placed upon the indicator it should be calibrated against a reliable steam gage. This is accomplished by mounting the indicator on a steam drum in which the pressure can be throttled. The indicator is mounted on this drum and placed under various steam pressures. At each pressure a horizontal line is drawn on the indicator card with the indicator pencil. By measurement of the height of these pressure lines above the atmospheric line, the accuracy of the instrument can be determined. After calibration, the ammonia indicator is mounted on the compressor and a typical card taken of the machine working under the load.

*Professor of Mechanical Engineering, University of Tennessee.



APPROXIMATE METHOD OF OBTAINING VOLUMETRIC EFFICIENCY OF AMMONIA COMPRESSOR FROM AN INDICATOR CARD

The area of the rectangle B R M S divided by the area of the rectangle P O M N equals the value of the volumetric efficiency.

INDICATOR DIAGRAM

A typical diagram obtained from an ammonia compressor is shown in the accompanying illustration. The length of the diagram A corresponds to the stroke of the compressor to some reduced scale. The length A does not include the piston clearance, but represents only the moving stroke of the piston. The curved line BC is the typical compression line for ammonia. This line rises in pressure above the discharge pressure of the machine to a point sufficiently high to open the valve. The reasons why this pressure must exceed the discharge pressure are:

(1) The friction of the valve mechanism must be overcome in addition to the pressure of the gas on the opposite side.

(2) The lower side of the valve usually is slightly less area than the top side due to its conical design. This means that there are more sq. in. of opposing force on the upper side of the valve than there are sq. in. of lifting force on the lower side of the valve. This necessitates, therefore, greater lifting force per sq. in. on the lower side of the valve.

As can be noted on line CD, the pressure immediately drops as soon as the valve opens at point C. The valve closes at the end of the forward stroke at which time the pressure equals the discharge pressure.

Depending upon the amount of clearance, a certain amount of ammonia will be left in the cylinder and as the piston starts on the back stroke the cylinder space back of the piston will be filled with this left-over ammonia. The greater the clearance, the more ammonia

will be left in the cylinder back of the piston, and the longer period of time it will require for the pressure back of the piston to drop to the suction pressure of the system. This is shown on the drawing by the relative positions of E and E^1. E represents a small clearance with little ammonia left in the cylinder and a rapid drop of the suction pressure. E^1 represents a large clearance with considerably more ammonia left in the cylinder and a slow drop of the suction pressure. As is indicated on the diagram, the pressure within the cylinder falls below the suction pressure of the system and fills the space back of the piston with ammonia. Throughout the suction stroke, from F to B, the pressure will remain considerably below the system suction pressure.

As is represented on the diagram, the distance H is measured between the two vertical lines projected from D to E respectively. E is the point where the suction line of the indicator and the suction pressure line of the system cross.

Clearance

The clearance of the machine will be represented by H and the volumetric efficiency can be determined by analysis as shown by the rectangles in the accompanying illustration.

The rectangle M N O P is constructed equal to the length of the indicator diagram with the height equal to the distance from the absolute zero-pressure line to the suction pressure line. A second rectangle is formed, M S R B, again using the absolute vacuum line for a base and a height equal to M B or the distance from absolute vacuum to suction pressure line of indicator diagram.

The volumetric efficiency of the machine can now be computed by determining the areas of these two rectangles. The area of the smaller rectangle divided by the area of the larger rectangle will give the value of the volumetric efficiency. Or:

$$\frac{\text{Area of M B R S}}{\text{Area of M N O P}} = \text{Volumetric efficiency}$$

After determining the volumetric efficiency of the machine, the next procedure is that of determining the theoretical displacement on the basis of 100 per cent volumetric efficiency. This will equal the volume of the cylinder multiplied by the number of strokes per minute. When this value is determined, the product of the true volumetric efficiency and the theoretical displacement per minute will equal the actual cubical displacement of the machine at the observed suction and discharge pressures.

Most handbooks on refrigeration give the actual displacement required per ton of refrigeration at different suction and discharge pressures. The computed actual displacement of the machine indicated divided by the tabulated displacement required per ton would give the tons of refrigeration per hour of the machine under test.

The errors that creep into such a test may easily total 6 to 8 per cent. The errors due to indicator lost motion, indicator inertia and the indicator spring are usually appreciable. In addition to this, the available tables seldom show any correction to be made for superheat in the ammonia cycle, but under actual operation superheat affects the output of the machine very noticeably.

As an acceptance test, the indicator method should be used only when both buyer and purchaser agree to accept it as satisfactory with the full understanding that the results obtained are only approximate.

Rickety Transmission

By W. F. Schaphorst

NOT LONG ago, I was invited to visit a small textile mill in one of the New England states.

What impressed me most on looking it over, was the home-made transmission equipment which certainly wasn't very efficient. Hangers were built entirely of wooden two-by-fours, nailed together. Each hanger creaked loudly and each one creaked in a pitch all its own, out of harmony with the others. Fortunately the shafting didn't run at high speed or the noise would have been unendurable. Even as it is, I am sure that this small New England mill is far noisier than other mills many times larger.

The bearings were made of ordinary pipe sawed off and bolted to the wooden hangers by means of metal straps. Of course there was no such thing as "fit" between the shaft and bearings. They operated with extreme looseness and rattle. Altogether the rattling, creaking and shrieking reminded me of the noise one hears on Broadway every election night. It was terrible.

Transmission of that sort is decidedly inefficient. Power is obtained from a stream that flows past, but it is insufficient for the owners' entire needs and they are obliged to buy additional power from a central power station. They probably think that they are getting most of their power for "almost nothing." But not so. By installing up-to-date hangers, bearings, and shafting, the mill could be speeded up, production increased, power saved and noise eliminated, and they would then have a mill of which they could be proud. As it is now operated, they certainly are not proud of it. They "wish" they had better hangers, bearing, belting and shafting. They "wish" they could speed up. They "wish" the mill were less noisy. They "wish" they could compete more readily with modern mills.

There can be no question but that their brand of economy is expensive. With such out-of-date equipment, it is exceedingly difficult to compete these days. I will wager that they are losing enough money because of poor transmission equipment alone, to pay for several complete installations of modern transmission equipment each year.

Rickety transmission is usually symbolic of a rickety business organization.

The Municipal Utilities Company, Des Moines, Iowa, has been granted franchise to install and operate a $147,000 electric light and power plant in Emmetsburg, Iowa, under contract which provides that upon repayment to the utilities company, which is virtually a financing company, the plant becomes property of the city. It is expected to reach this stage within a decade.

Trinidad Station Burns Powdered Lignite

PULVERIZED TEXAS LIGNITE BURNED IN NATURAL DRAFT WATER COOLED FURNACES, OPERATING CONDITIONS 400 LB., 750 DEG. F., NO ECONOMIZERS OR PREHEATERS USED. PRESENT CAPACITY 40,000 KW. IN TWO UNITS, TURBINES BLED AT THREE POINTS. BY EDW. C. KECK*

TRINIDAD STEAM electric station of the Texas Power & Light Co. is located on the east bank of the Trinity River about a mile and a half south of the village of Trinidad and 65 mi. southeast of Dallas, Texas. The site is within 10 mi. of an area containing an adequate quantity of lignite.

Reliability and continuity of fuel supply are assured by the proximity of the mines and, while a large proportion of the fuel burned will be supplied from shaft mines, deposits of lignite, sufficient for six months' supply, are stripped in advance so that fuel may be delivered to the station by only a shovel and train crew. In addition, a month's fuel supply is kept in storage at the plant for emergency purposes to insure against failure of delivery from the mines.

Four Babcock & Wilcox cross drum sectional header type boilers with a heating surface of 18,756 sq. ft. and with 4000 sq. ft. of interdeck superheaters are installed. They are designed for a maximum steam pressure of 425 lb. gage and a total temperature at the superheater outlet of 750 deg. F., although normal boiler operating conditions are 400 lb. gage, 735 deg. F. total temperature. The absence of preheaters or economizers and the use of natural draft contribute to the simplicity of operation of the station.

Each pair of boilers is served by a reinforced concrete stack 300 ft. high above the boiler room roof, 12 ft. inside diameter at the top and supported by the building steel. Each furnace is approximately 25 ft. square inside the arch and 35 ft. high from the slag screen to the lower boiler tubes. The ash pit with 30 deg. and 60 deg. sloping sides has a maximum depth below the slag screen of 12 ft. The water wall and slag screens are all connected by external headers to the boiler circulation, their 2520 ft. of heating surface giving each boiler a total heating surface of 21,276 sq. ft.

COAL DRIED ON STEAM DRYERS

Furnace volume above the ash pit is 18,540 cu. ft. or the equivalent combustion chamber volume of 0.988 cu. ft. per. sq. ft. of boiler heating surface and 0.871 cu. ft. per sq. ft. of heating surface, including the surface in the water cooled walls and slag screen. Pulverized Texas lignite is used as fuel. Steam coal dryers are located directly under the crushed lignite bunkers and are of the steam grid type supplied with steam at 10 lb. gage bled from the 7th stage of the turbine or, if necessary, taken directly from the saturated steam header through reducing valves.

The two main turbines are 20,000-kw., 14-stage, 1800-r.p.m. single cylinder General Electric units, designed for a steam pressure and temperature of 375 lb. gage and 700 deg. F. at the throttle and bleeding from the 3rd, 7th and 11th stages. Each turbine exhausts into a 20,000-sq. ft. single pass Foster Wheeler Corp. surface condenser having Admiralty metal tubes rolled at both ends into the Muntz metal tube sheets. Two 30-in., 20,000-g.p.m. circulating pumps driven by 2-speed induction motors are provided for each condenser.

As the flow of the Trinity River varies from 20 sec. ft. to 75,000 sec. ft. with the period of minimum flow generally occurring at the time of the system peak load, it was necessary to create an artificial cooling lake to which water would be supplied by pumping from the river. This lake has a total area of about 650 acres, sufficiently large so that natural cooling can be depended upon, making it possible to dispense with a spray pond.

Both of the present main generators are rated at 25,000 kv.a., 12,000 v., star connected with neutrals grounded through non-automatic remote controlled oil circuit breakers. Each generator is connected directly to a bank of three 8333-kv.a. outdoor water cooled transformers which are wound for 60,000 and 132,000 v. on the high side.

HOUSE TURBINE FLOATS ON LINE

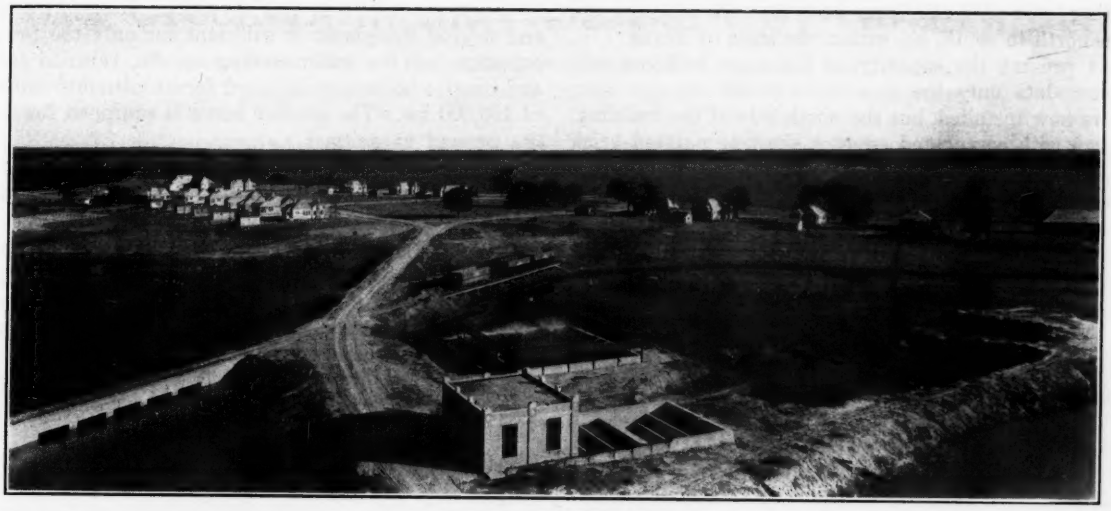
Station auxiliary power is normally taken from each generator lead by 2000-kv.a., 3-phase, 12,000 to 2300-v. transformers. When neither machine is operating or these transformers are not in service, auxiliary power is taken from the 60-kv. bus by a 2000-kv.a., 3-phase, 60,000 to 2300-v. transformer. In case of failure of both of these sources, the auxiliary load can be carried by the 1200-kw., 3600-r.p.m. single stage non-condensing house turbine which normally carries no load. The generator floating on the auxiliary bus as a synchronous condenser is arranged to pick up the load automatically when 3 per cent drop in frequency occurs.

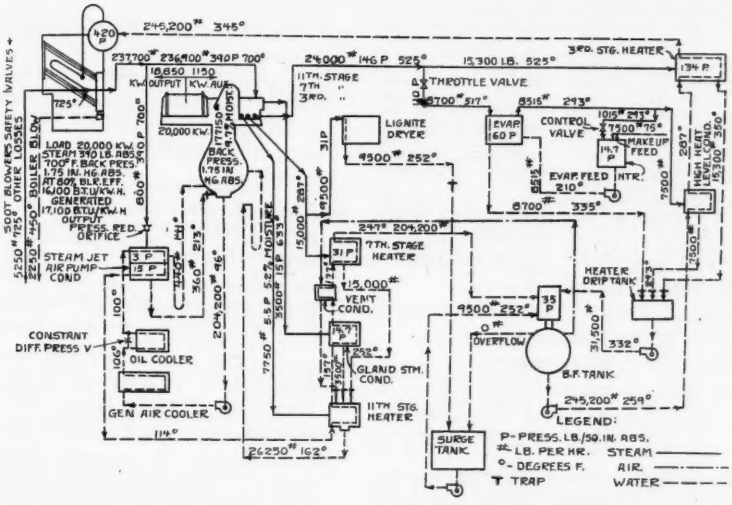
All motors are 2200 or 220-v. constant speed squirrel cage type with the exception of the circulating pump motors which are two speed. In general, all motors smaller than 50 hp. are 220 v. and those 50 hp. and larger 2200 v. All of the control and metering equipment is located in the control house which is 130 ft. west of the main turbine building between the 60,000 and 132,000-kv. switch structures. Besides metering panels and control benchboards for the generators, 60-000-v. feeders and 132,000-v. feeders, the control house is equipped with turbine room telegraph, steam gage and exciter control panel. All switching is done at 60,000 and 132,000 v.

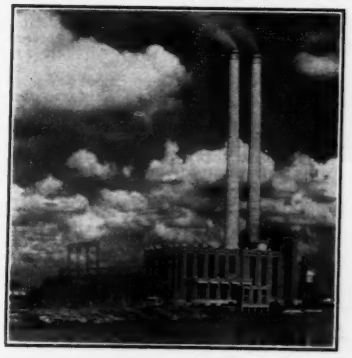
ULTIMATE CAPACITY 160,000 KW.

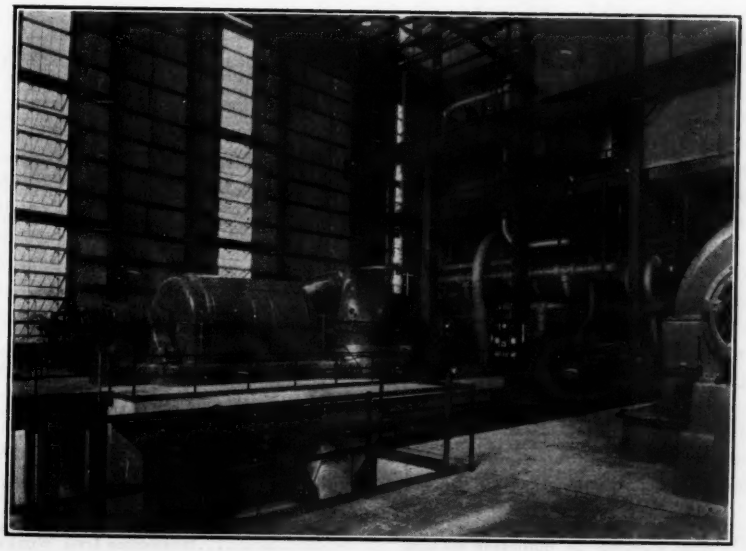
Trinidad is a base load station, but the extent of the system necessitates the division of load with several other stations for voltage regulation and prohibits carrying the entire load on the most economical plants at times of light system load. The 2400 mi. of transmission making up the company's transmission system extends 290 mi. from north to south, 260 mi. from east

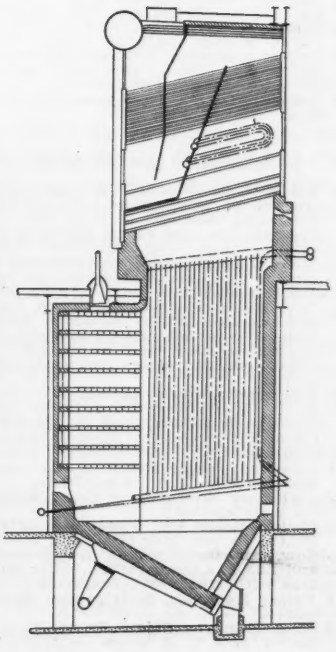
*Supt. of Power, Texas Power & Light Co., Dallas, Tex.




245,200# 345°
237,700# 236,700# 390 P 700°
24,000# 146 P 525°
15,300 LB. 525°
3RD. STG. HEATER
134 P
11TH. STAGE
7TH "
3RD. "
THROTTLE VALVE
8700# 317°
8518# 293°
LIGNITE DRYER
EVAP. 160 P
CONTROL VALVE
1015# 293°
7500# 75°
MAKE UP FEED
14.7 P
EVAP. FEED HTR.
210°
8700# 335°
HIGH HEAT EXCH.
15,300# 390°
9300# 252°
15,000# 281°
247° 204,200#
7TH. STAGE HEATER
31 P
HEATER DRIP TANK
35 P
9300# 252°
715,000#
VENT COND.
OVERFLOW
31,500#
332°
GLAND STM. COND.
8.F. TANK
245,200# 259°
11TH STG. HEATER
SURGE TANK
26250# 162°
LEGEND:
P-PRESS. LB./SQ.IN. ABS.
#-LB. PER HR.
°-DEGREES F.
T TRAP
STEAM
AIR
WATER
STEAM JET AIR PUMP COND
OIL COOLER
GEN. AIR COOLER
CONSTANT DIFF. PRESS V
LOAD 20,000 KW
STEAM 390 LB. ABS.
700° F. BACK PRES.
1.75 IN. HG ABS.
AT 80% BLR. EFF.
16,100 B.T.U./K.W.H.
GENERATED
17,100 B.T.U./K.W.H.
OUTPUT
PRESS. RED. ORIFICE
SOOT BLOWERS SAFETY VALVES + OTHER LOSSES
BOILER 81.0%
20,000 KW.
KW. OUTPUT
KW. AUX.
BACK PRESS. 1.75 IN HG ABS.







to west, and is a part of an inter-connected system extending over 500 mi. from east to west and 400 mi. from north to south, all within the state of Texas.

At present the capacity of the main building will accommodate only the two turbo-generators and four boilers now installed, but the north side of the building, covered with corrugated asbestos sheeting painted brick red to harmonize with the permanent wall, is temporary to allow expansion in this direction. The pulverizing and drying equipment is sufficient for only the present capacity, but the water cooling system, railroad tracks and control house are designed for an ultimate capacity of 160,000 kw. The crusher house is equipped for twice the present capacity.

Principal Equipment in the Trinidad Station

General

Location.....Trinity River, Near Trinidad, Texas
Company.....Texas Power & Light Co.
Present Capacity ..... 40,000 kw.
Ultimate Capacity .....160,000 kw.
Station Site .....1,600 acres
Artificial Lake for Circulating Water .....650 acres

Turbo Generators and Auxiliaries

2 General Electric Co., 20,000 kw., 1800-r.p.m., 14-stage turbine driving 25,000-kv.a, 12,000-v., 3-phase 60-cycle generators and 120-kw., 250-v. shunt wound direct connected exciters. Turbines bled at the 3rd, 7th and 11th stages.
2 Foster Wheeler Corp. 20,000 sq. ft. horizontal single pass surface condensers with admiralty tubes rolled into both tube sheets.
4 Foster Wheeler Corp. 20,000 g.p.m., against a total head of 21 ft. circulating pumps, each driven by 150 hp., 2200-v., 3-phase, 2-speed General Electric Co. induction motor.
4 Foster Wheeler Corp. centrifugal condensate pumps with capacity of 440 g.p.m. against a total head of 210 ft., each driven by 40 hp., 2200 v., 3-phase General Electric induction motor.
2 Foster Wheeler Corp. 2 stage steam jet vacuum pumps, size F.
2 Foster Wheeler Corp, size E single stage steam jet priming ejector.
2 General Electric Co. fin type generator air coolers with a surface of 15,000 sq. ft. each.
1 General Electric Co. 1200 kw., single stage, 3600 r.p.m., non-condensing turbine driving a 1500 kv.a., 2300 v. 3-phase, 60-cycle generator and a 17-kw., 250 v., compound wound exciter.
1 General Electric Co. 150-kw., 250-v., shunt wound auxiliary exciter direct connected to a General Electric Co. 225-hp., 2200-v., 1200 r.p.m. squirrel cage induction motor.
2 General Electric Co. steam flow meters.

Boilers and Auxiliaries

4 Babcock & Wilcox Co. sectional, cross drum, water tube boilers with a heating surface of 18,756 sq. ft. designed for a working pressure of 425 lb. gage, and equipped with 4000 sq. ft. interdeck superheaters to give a total steam temperature of 750 deg. F.
4 Combustion Engineering Corp. Lopulco water cooled furnaces with 2520 sq. ft. of water wall and screen heating surface and a volume of 18,540 cu. ft. above the ash pit screen.
4 American Arch Co. arches.
4 B. F. Sturtevant Co. primary air fans, each driven by a 75 hp. 1800 r.p.m. 2200 v. General Electric induction motor.
4 Diamond Power Specialty Co. soot blowers with 22 units per boiler.
4 Girtanner Engineering Corp. steam jet soot ejectors.
4 Bailey Meter Co., Type D-26, 0 to 200,000 lb. per hour recording steam flow, air flow, steam temperature and flue gas temperature boiler meters with steam flow indicator.
4 Bailey Meter Co. Multipointer draft gages.
3 A. S. Cameron Steam Pump Works No. 5 H. S. T. 6 stage centrifugal boiler feed pumps with a capacity of 700 g.p.m. each against a total head of 1155 ft. Each driven by a 350 hp. 2200 v. General Electric Co. induction motor.
1 A. S. Cameron Steam Pump Works, Type H. M. T. 5 stage centrifugal boiler feed pump with a capacity of 700 g.p.m. against a total head of 1155 ft., driven by 350 hp. Type GS Terry turbine.
8 Northern Equipment Co. Copes feed water regulators. Two regulators per boiler.
8 Swartwout Co. S.-C Type "S" excess pressure regulators. Two per boiler.
8 Foster Wheeler Corp. horizontal closed type floating head feedwater heaters with the following surfaces: 11th stage heaters 750 sq. ft.; 7th stage heaters 837 sq. ft.; 3rd stage heaters 1290 sq. ft.; Gland steam heaters 287 sq. ft.
2 Foster Wheeler Corp. Contraflo single effect evaporator units (2 per unit). Capacity of 10,000 lb. per hr. per unit. Equipped with Atwood & Morrill drainers, Cochrane Corp. 9,000 lb. per hr. deaerating heater and Cochrane 820 sq. ft. high heat level condenser.
3 Goulds Pumps, Inc., centrifugal evaporator feed pumps with a capacity of 30 g.p.m. against a total head of 145 ft., each pump driven by a 5 hp. 220 v. General Electric Co. induction motor.
Breechings-Connery & Co.

Water Treating Plant Equipment

2 International Filter Co. Style L 78 in. diameter pressure filters.
2 Permutit Co. water softeners with a total capacity of 26,100 lb. per hr., each tank 5 ft. diam. by 8 ft. 4 in. high.
1 Wallace & Tiernan Co. domestic water treater or chlorinator with a capacity of 100,000 gal. filtered water per day.

Fuel Preparation, Burning and Handling Equipment

1 Fairbanks Co. 250,000 lb. track scale.
2 Merrick Scale Mfg. Co. weighmeters with a capacity of 100 t. per hr. each.
2 Stephens-Adamson Mfg. Co. apron feeders with capacity of 100 t. per hr. each, each feeder driven by 7½ hp., 220-v. General Electric Co. induction motor.
2 Stephens-Adamson Mfg. Co. crusher units, with 2 crushers per unit of single roll Pennsylvania Armorframe 24 in. by 50 in. with a vibrating screen between primary and secondary crushers. Each crusher driven by a 50-hp., 220-v. General Electric Co. induction motor.
2 Stephens-Adamson Mfg. Co. v. bucket type elevator conveyors with a capacity of 100 t. per hr. each. Each conveyor driven by a 25-hp., 220-v. General Electric Co. induction motor.
4 Stephens-Adamson Mfg. Co. belt conveyors, each driven by a 5-hp., 220-v. General Electric Co. induction motor.
1 Stephens-Adamson Mfg. Co. Crescent drag scraper for lignite storage, driven by a 75-hp., 2200-v. General Electric Co. induction motor.
6 Combustion Engineering Corp. screw type pulverized fuel conveyors driven by 20 and 25-hp. 220-v. General Electric Co. induction motors.
4 Combustion Engineering Corp. 4-stack (45 grids per stack) steam grid coal dryers.
4 Combustion Engineering Corp. six-roll Raymond pulverizing mills with a capacity of 15 t. per hr. each. Each mill driven by a 200-hp., 2200-v. General Electric Co. double squirrel cage induction motor.
48 Combustion Engineering Corp. Lopulco screw feeders (12 per boiler) driven in groups of 6 by 7½ hp. 220 v. constant speed motors through Reeves variable speed transmissions.
48 Combustion Engineering Corp. Lopulco fantail burners.
1 Atlas Car & Mfg. Co. 25 t. storage battery locomotive.

Ash Handling Equipment

Ash conveyors .....Combustion Engineering Corp.
Ash Skip hoist.....Stephens-Adamson Mfg. Co.
Ash bunker.Stephens-Adamson Mfg. Co.
Ash cars .....Western Wheeled Scraper Co.

Miscellaneous

Makeup Pumps for lake water.....Worthington Pump & Machy. Corp.
Fire pumps.....Allis-Chalmers Mfg. Co.
House service pumps.....Allis-Chalmers Mfg. Co.
Surge tank pumps..Goulds Pumps, Inc.
Sump pumps.....Goulds Pumps, Inc.
Domestic water supply.....American Well Works
Vacuum Cleaning System.....Allen & Billmyre Co.
1 Ingersoll-Rand Co., 2 stage belt driven 384 cu. ft. at 110 lb. gage air compressor driven by 100 hp. 2200 v. Westinghouse induction motor.
1 Whiting Corp. 100 t. turbine room crane.
2 Heine Chimney Co. reinforced concrete chimney 300 ft. high above roof, 16 ft. inside diameter at base, 12 ft. inside diameter at top.
2 Chicago Bridge & Iron Works 50,000 gal. water tanks on towers.

Electrical Equipment

7 Westinghouse Elec. & Mfg. Co. 8333 kv.a. 136,800 and 64,800 Y to 12,000 v. delta single phase water cooled outdoor type main transformers.
3 General Electric Co. 2000 kv.a 12,000 to 2300 v. 3 phase self cooled auxiliary transformer.
1 General Electric Co. 2000 kv.a 60,000 Y to 2300 v. Delta, three phase self cooled standby auxiliary transformer.
29 General Electric Co. 2300 to 115 and 230 v. single phase oil cooled auxiliary transformers as follows: 6-150 kv.a.; 16-100 kv.a.; 4-37½ kv.a.; 3-25 kv.a.
2 General Electric Co. 35 kw. motor generator sets.
1 General Electric Co. 5 kw. 140 v. battery charger.
Synchronizing equipment — General Electric Co., 132 kv. condenser type vacuum tube amplification.
Storage battery—Electric Storage Battery Co., Type E-17, 60 cell, 120 v. 320 amp. hr. storage battery.
Oil Circuit Breakers and Disconnect Switches...Pacific Electric Mfg. Co.
Grounding Switches and Choke Coils .....Burke Electric Co.
Switchboard and Control Panels.....General Electric Co.
Switchyard structure .....Muskogee Iron Works

Cove Creek Dam May Be Built by Government

MUSCLE SHOALS BILL OF HOUSE OF REPRESENTATIVES AUTHORIZES STILL FURTHER COMPETITION WITH PRIVATE INDUSTRY IN TENNESSEE. BY WINGROVE BATHON*

THERE IS an outstanding feature of the Muscle Shoals bill, favorably reported by the Military Committee of the House of Representatives, covered in Sections 17 and 18 of the bill; these sections deal with what has come to be known as the Cove Creek Dam. They provide that the Secretary of War be authorized, with appropriations hereafter to be made available, to construct, either directly or by contract to the lowest responsible bidder, a dam in and across the Clinch River in the State of Tennessee, including power house and hydroelectric installations and equipment, for the generation of at least 200,000 hp. This, it is specified, is for the purpose of increasing the amount of primary power to be developed at the Wilson Dam at Muscle Shoals and any and all other dams below Cove Creek Dam.

About the time this is published, the House bill will probably be under debate on the floor of the House or in conference. It is, therefore, timely and interesting to examine the situation in connection with the supply of power for Tennessee, Alabama and other southeastern states, which is brought up in connection with the Cove Creek Dam. There are on file with the Federal Power Commission applications by private industry to construct the Cove Creek Dam, as well as 10 other dams on the Tennessee, Powell and Clinch Rivers in connection therewith. These applications were made 2 yr. ago by the East Tennessee Development Co. and another group of applications was made by the Union Carbide Co. Also, one of the private bidders for Muscle Shoals, or rather the group represented by the American Cyanamid Co., the Union Carbide Co. and the Air Nitrates Corp. required in their bid that the Government should build the Cove Creek Dam within a certain period of time or give them the preferential right to do so.

TABLE I. ITEMIZED ESTIMATES OF COST OF PROPOSED COVE CREEK DAM

Cofferdams	300 lin.ft.	$125.00 lin.ft.	$43,750
Earth Excavation	33,427 cu.yds.	1.00 cu. yd.	33,427
Rock "	33,515 " "	4.00 " "	126,060
Preparing Foundations	26,832 sq.ft.	.40 sq.ft.	10,732
Concrete Draft Tube and Intake Sections	61,324 cu.yds.	12.00 cu.yd.	735,888
Steel Prestocks		Lump Sum	150,000
Building Structure		" "	514,500
Sash, Doors, Skylights		" "	35,000
Heating, Lighting & Power		" "	30,000
Tiling, Painting & Finishing		" "	25,000
Turbines and Governors		" "	763,200
Generators and Exciters		" "	1,100,400
Switchboard and L.T.Wiring		" "	312,000
Transformers and H.T.Equipment		" "	630,000
Auxiliaries		" "	187,500
Head Gates, Gantry and Tracks		" "	200,000
TOTAL POWER HOUSE			$4,903,457

In all of the estimates of cost during the past 2 yr., the testimony has been to the effect that the building of this dam would represent an expenditure of about $20,000,000. The Rivers and Harbors Board of the War Department, however, which has just completed a special new survey of the Tennessee River at a cost of $1,000,000, has considerably raised this cost. The latest estimate of these Government engineers is that the total cost of this Cove Creek Dam will be $37,540,643. To this the Army engineers add for an initial transmission line the sum of $6,043,397, making the grand total cost of the dam, hydroelectric works and transmission line $43,584,040.

*Washington Correspondent of Power Plant Engineering.

COSTS OF PROPOSED COVE CREEK PROJECT

Cost of the main dam is given as $7,141,131; the cost of the spillway is given as $1,861,875; the cost of the barge lift is given as $2,634,516; the cost of the reservoir, including land, clearings, railroad relocations, etc., is given as $11,318,745; general costs, including construction camp, plant, railroad, engineering fees, legal fees, etc., are given as $6,268,131. Power house costs, given as $4,903,457, are itemized in Table I and initial transmission line costs in Table II.

TABLE II. ITEMIZED ESTIMATE OF PROPOSED COVE CREEK TRANSMISSION LINE COST

Right of Way	250 miles	$500.00 mile	$125,000
Clearing	50 "	2,000.00 "	100,000
Towers and Extensions	1,750 "	1,000.00 each	1,750,000
Distribution & Erection	1,750 "	125.00 "	218,750
Excavation for Foundations	7,000 holes	5.00 "	35,000
Foundations	7,000 "	20.00 "	140,000
Conductors	8,580,000 lbs.	.17 lbs.	1,458,600
Distribution & Stringing	1,500 miles	100.00 mile	150,000
Ground Wires	1,029,600 lbs.	.08 lb.	82,368
Distribution & Stringing	500 miles	50.00 mile	25,000
Insulators in Place	210,000 units	3.00 unit	630,000
Insulator Hardware	10,500 sets	10.00 set	105,000
Carrier Telephone Equipment		Lump Sum	15,000
NET TOTAL COST OF INITIAL TRANSMISSION LINE			$4,834,718
ENGINEERING, OVERHEAD AND CONTINGENCIES 25%			1,208,679
GRAND TOTAL COST OF INITIAL TRANSMISSION LINE			$6,043,397

Since all engineering reports in regard to the Tennessee River stress the vital importance of the Cove Creek Dam to any plan for the development of the basin, either in connection with Muscle Shoals or for any other purpose, it is not surprising that the House Military Affairs Committee insisted upon including the authorization for the building of the Cove Creek Dam by the Federal Government in the Muscle Shoals bill. On the other hand, not only has the East Tennessee Development Co. stood ready for several years to build this and a group of other dams on the Tennessee, Clinch and Powell Rivers with private funds, but also the Tennessee delegation in the House and Senate is opposed to the Government going into the power business at Cove Creek Dam, 400 mi. away from Muscle Shoals. Most of the forward-looking people in Tennessee would rather have private industry build these dams so that these works would yield taxation for the benefit of the support of the state in such matters as road building, education and the like.

There is a possibility that Sections 17 and 18 will be stricken out of the Muscle Shoals bill either on the floor of the House or when the bill, if passed by the House, goes into conference with the Norris Muscle Shoals bill in the Senate. In the discussion of Muscle Shoals in the Senate, many senators from other states sympathized with the point of view of the Tennessee senators. It

should be noted that in the table giving the initial transmission line costs, the right-of-way of 250 mi. is an air-line right-of-way, although the distance by river is 400 mi.

But, irrespective of whether the Cove Creek Dam is stricken out of the Muscle Shoals bill or not, it is likely that the agitation that this dam-site should be developed by the United States in connection with Muscle Shoals will prevent, or at least delay for a number of years, approval of any application for the building of the Cove Creek Dam by private industry. In that case, those who desire to build this dam and other dams for the purpose of furnishing additional power facilities for East Tennessee, must either develop some other watershed or build steam plants.

The useful storage capacity of the Cove Creek Dam, the engineers estimate, will be 98,000,000,000 cu. ft. In 1884, the United States installed and placed in operation at the head of the Mississippi River in Minnesota a large storage reservoir system, which was increased later, making the total storage capacity in that section 94,000,000,000 cu. ft. That was to benefit navigation on the Mississippi and increase hydro-electric capacity down the stream as far as St. Paul. The cost of those reservoirs on the Mississippi was about $2,000,000. The cost of the Cove Creek reservoir, without the transmission line, being about $37,500,000, shows that the cost of the Cove Creek reservoir will be eighteen times as much as that of the Upper Mississippi per cubic foot of storage capacity.

Cove Creek Dam Would Furnish Dump Power

One of the outstanding features of the whole Cove Creek reservoir controversy is that the power to be obtained therefrom will be nothing but dump power. The reservoir gates will have to be closed for months at a time when the natural flow of the Tennessee is sufficiently large. The engineers estimate that the gates will have to be shut down sometimes for an aggregate of 6 mo. and, of course, at those times there will be no power available at Cove Creek. Dump power, being low-priced power, can be used advantageously only when it is tied in with other powers and until other big reservoirs are developed. The most recent report of the Rivers and Harbors Board of the War Department estimates a total cost of about $1,000,000,000 to develop and create storage reservoirs for the whole river. If Congress adopts the provision in the House Muscle Shoals bill for Federal building of the Cove Creek Dam, it will probably be just the first step in the building of other Federal dams along the river.

Section 17 of the House Muscle Shoals bill requires the Federal Power Commission to compel contribution by any person, firm or corporation that it may hereafter permit, authorize and empower to build a dam or dams in the Clinch River and in the Tennessee River below the Cove Creek Dam, when such person, firm or corporation receives benefits from the equalizing of the volume of water in the Clinch River and in the Tennessee River below the Cove Creek Dam. The experience of the Federal Government in the Upper Mississippi in regard to this feature of storage reservoir operation has been one of strife and turmoil, during which farming communities fought municipalities and municipalities fought power developments. There was a hearing before the Board of Engineers for Rivers and Harbors in Washington, the latter part of March, on the subject of these reservoirs, during which this strife and turmoil was acrimonious. The War Department district engineer recommended that the Upper Mississippi reservoir system be abandoned and the reservoirs sold or leased for what they might bring. It is always difficult to establish the measure of benefit down-stream from reservoirs above. The War Department has never yet succeeded in establishing and collecting the Upper Mississippi reservoir benefits and the Federal Power Commission, although it is instructed in the Federal Power Act to see that such benefits are collected, has not yet worked that matter out.

Opposition to the Bill

As soon as the House Muscle Shoals bill reached the United States Senate, and as soon as it was reported in the newspapers in Tennessee and the surrounding country, as well as in the State of Arizona and in the other six states interested in the Boulder Dam bill, reaction against the Cove Creek provisions of the bill began to set in. This was manifested in the Senate by Senator Tyson of Tennessee and Senator Ashurst of Arizona, both of whom strenuously objected to the proposed invasion of the rights of their states by the Federal Government, as they see it.

Senator Ashurst served notice on the Senate, in a brief speech in regard to the Boulder Dam bill, that he regards that bill as a "reckless and relentless attempt to over-ride the state of Arizona," characterizing the Boulder Dam bill as "one of the most cynical, sinister and ruthless attempts ever made in the history of this Government to over-ride the constitutional rights of a state." Senator Tyson had presented to the Senate telegrams from Tennessee objecting to the Federal Government taking possession of the water rights in the Tennessee River within the State of Tennessee and Senator Ashurst declares that under the Boulder Dam bill the Federal Government assumes a similar position in regard to the water rights of the Colorado River so far as Arizona is concerned. Senator Ashurst formally served notice on the Senate that he would keep it in session "until the ides of November" before the Boulder Dam bill shall pass with the provisions in it which he objects to on the part of Arizona.

Thus the issue is drawn in Congress, with the proposed building of the Cove Creek Dam by the Federal Government as an object lesson. There will undoubtedly be a straight-out vote on both the Muscle Shoals bill and the Boulder Dam bill as to the important principle involved; namely, whether or not the Federal Government does invade the sovereignty of a state by such provisions.

The Duke Power Co., Charlotte, N. C., has approved plans for a new steam power at River Bend on the Catawba River, near Mount Holly, N. C., about 12 mi. from Charlotte. The initial capacity will be 150,000 hp. with arrangements to increase to 500,000 hp. later. The plant will be designed to burn pulverized fuel and it is planned that storage space will be provided for 100,000 t. of coal.

Overfire Air Injection Mixes Furnace Gases

In Some Cases it Offers a Method of Increasing Performance and Efficiency of Old Plants

REPORTS of experiments with overfire air injection on chain grate stokers of the Commonwealth Edison Co. prompted the trial of a similar installation on an underfeed stoker fired boiler unit at the Commerce St. plant of the Milwaukee Electric Ry. & Lt. Co., Milwaukee, Wis. Results of these tests are reported by the N. E. L. A. Gas analysis made in the first pass of the tubes when outfitting the unit with an air flow gage for CO_2 regulation showed obvious need for some method of supplying air at the point needed and curtailing it where not needed. Figure 1 shows the plotted data

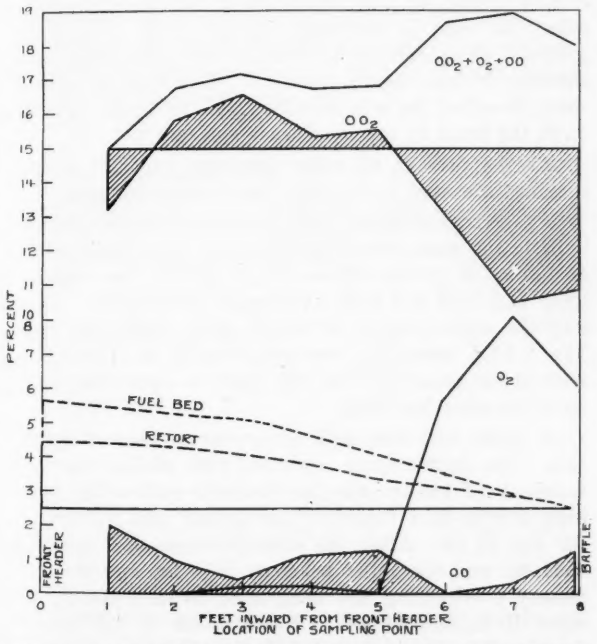


FIG. 1. VARIABLE CONDITIONS OF COMBUSTION EXISTING ACROSS THE STOKER FIRE, BOILER NO. 11, COMMERCE ST. STATION, PREVIOUS TO OVERFIRE AIR INJECTION

taken especially to determine if the trial installation should be made.

Features of smoke prevention offered by overfire air injection are particularly attractive for this station as it is located almost centrally in the city of Milwaukee and burns about 115,000 t. of coal annually. Of the 24 boilers, 8 have limited combustion space with combustion rates of 50,000 B.t.u. per cu. ft. per. hr. and smoke elimination was difficult. The data in Fig. 1 were obtained from one of the remaining 16 units.

Obviously a supply of overfire air at the coking part of the fire would eliminate the deficiency of oxygen at that point and cause combustion of the 1 to 2 per cent CO measured there. By supplying some of the combustion air above the fire the excess air through the dump end of the grate would be diminished with resultant decrease in total excess air.

Details of the first application are shown in Fig. 2. Air from the wind box is forced through an 8-in. pipe to ten 1½-in. nozzles set in the short arch wall as shown. Resistances are such that about 5 per cent of the total combustion air flows through these nozzles requiring no booster fan. Variable ratings require no adjustment of overfire air flow for the wind-box pressures change in the desired proportion with rating to maintain a nearly constant percentage of overfire air.

No measurements were necessary to prove the success of the original installation. By opening and closing the damper controlling the overfire air smoking could be changed from one extreme to the other. Using overfire air, the smoke periscopes were as clear as those with pulverized fuel fired boilers at Lakeside and the effect was almost instantaneous with rapid closing and opening of the dampers. Tests of the effectiveness of the

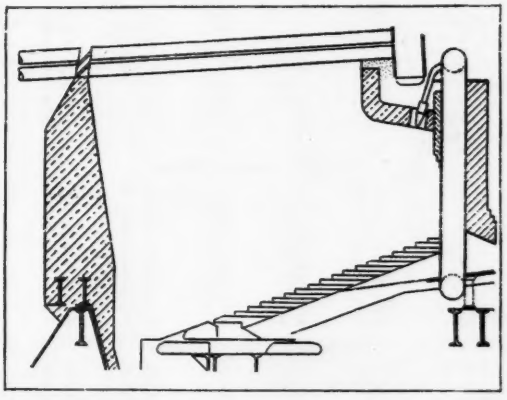


FIG. 2. METHOD OF APPLYING OVERFIRE AIR INJECTION NOZZLES TO AN EXISTING STOKER INSTALLATION

method made in this manner never failed to correct bad smoke conditions. Applied when starting the fire the method was equally effective. Figures in the table show quantitative results of gas analyses. Samples were taken through the hollow staples in the front header of the boiler just sufficiently above the first row of tubes so that the sample pipes could be maintained without special cooling. Measurements in the same position were made first with the damper closed and then with it open in order to eliminate any effects due to change in fire condition.

Total Savings of 7.8 Per Cent Indicated

On the basis of improvements in gas analysis in the last pass of the boiler the increase in boiler efficiency in the described case above equals 7.8 per cent, 1.3 per cent of which is due to an increase of CO_2, 6 per cent due to the total elimination of CO and combustible hydro carbon and 0.5 per cent of which may be credited to cleaner heating surfaces.

Later readings on a boiler unit having a considerably larger furnace volume showed comparable gains and the

smoke elimination was as positive as in the case of the smaller combustion space. In this latter case, the coal contained a portion of cannel-coal and it smoked considerably for that reason. With a better quality of coal, the overfire air was not necessary and in some cases of good coal it showed no improvement; therefore installations of this kind are not justified unless gas analysis or smoke conditions show that improvements can be made.

A year's experience with this method on 24 boilers has shown no undesirable effects. The brick work maintenance has not changed, the boilers are cleaner, the smoke conditions are obviously better and the appearance of the stacks approaches that of modern stoker plants.

Taking gas samples on all points above the furnace would indicate to anyone who contemplates overfire air injection whether improvements should be made in any particular case. It will be quite evident that in the older installations of under feed stokers burning high volatile coals that the proper injection of air can do much to even combustion conditions above the fire and to diminish unburned gases and carbon.

QUANTITATIVE RESULTS OF GAS ANALYSIS WITH AND WITHOUT OVERFIRE AIR INJECTION

Feet from Front Header	Near Center of Boiler — No Air Injection CO_2 %	O_2 %	CO %	With Air Injection CO_2 %	O_2 %	CO %
1	12.8	1.2	1.6	15.3	1.2	0
2	15.5	2.0	0.9	16.3	0.6	0
3	15.0	0.2	0.6	17.2	2.4	0
4	15.6	1.9	0.0	15.6	4.2	0
5	14.0	3.6	0.0	14.3	6.5	0
6	14.0	3.0	0.1	14.0	6.0	0
7	9.0	5.0	0.0	10.8	7.2	0
Average....	13.9	2.4	0.5	14.8	4.0	0
At North Side of Boiler						
1	10.8	4.7	3.5	15.8	1.2	0
2	15.0	1.0	0.1	15.6	0.6	0
3	13.5	1.5	0.0	14.8	2.4	0
4	12.5	2.5	0.0	13.6	4.2	0
5	8.0	6.2	0.3	11.0	6.5	0
6	10.3	6.7	0.2	11.2	6.0	0
7	1.0	6.0	0.0	8.0	7.2	0
Average...	10.9	4.1	0.6	13.3	4.0	0
At South Side of Boiler						
1	13.6	0.6	0.8	14.5	1.3	0
2	14.0	2.5	0.1	15.5	1.7	0
3	14.6	3.1	0.3	16.2	1.3	0
4	9.5	4.0	1.3	14.3	3.5	0
5	14.6	2.9	0.0	11.0	3.5	0
6	6.5	5.5	0.0	8.5	4.5	0
7	9.0	5.8	0.2	7.0	4.8	0
Average. ..	11.6	4.2	0.34	12.5	2.9	0

At Boiler Outlet — Over-fire Air Injection	No	Yes
Rating, hp.	910	1150
CO_2, %	13.5	14.3
CO, %	1.2	0
Smoke conditions, periscope lens.....	Obscured entirely	Clear

ELECTRIFICATION of agricultural regions and introduction of pulverized fuel in industrial plants were outstanding topics of the second annual power conference at the University of Iowa, Iowa City, at which nearly 100 utilities and industrial engineers and authorities participated.

Roller Bearings on Chain Grate Stokers

TESTS were recently made at the central station Moabit, Berlin, to determine how roller bearings would work under the heavy service of old chain grate stokers, how much fuel could be saved and how well lubrication with dry graphite would satisfy.

The first installation of four front and four rear roller bearings was in Dec., 1924. Two front and two rear roller bearings have already operated 6200 hr. After 5860 hr. of operation two of the front roller bearings were replaced. Two rear roller bearings were replaced because several rolls had broken loose from the guiding rings.

In April, 1926, roller bearings were installed in which the rollers run in replaceable steel boxes. Conclusive results on this improvement are not yet available. No wear is noticeable on the shaft. Dry flake graphite was placed in the bearing box before operation started; it was found practical. The tension screws were placed at the rear bearings and the tension passed on to the front by means of lever and pull rod.

At the present 98 roller bearings and 150 sliding bearings are used in the chain grate stoker drums.

At the beginning of 1925 two entirely identical boilers built in the same year, equipped with two double grates of 155 sq. ft. grate surface each, and with rear tension, lever and pull rod were thoroughly overhauled. Each had the same number of chain grate links and rods. The 2.2-kw. gear-drive motors running at 750 r.p.m. were of the same type and age, and the operating hours were the same for each.

A 10-hr. test was made after several days of operation. The double grate equipped with sliding bearings required 6.7 kw-hr.; the double grate with roller bearings, 5.9 kw-hr.; therefore the saving was 0.8 kw-hr. for the 10 hr. After the slide bearings had operated 3541 hr. and the roller bearings 3513 hr. and the customary overhauling had been done on each stoker, another 10-hr. test showed a consumption of 6.36 kw-hr. for the slide bearings and 5.58 for the roller bearings. The saving was 0.78 kw-hr.

Between these two tests, which were given 10½ months apart, the grates had operated continuously at a 4.1 in. per min. feed; firing was regulated only with a damper, the thickness of the coal bed (4 to 6 in.) and the use of a slice bar. The roller bearing-equipped stoker saved, therefore, 79 kw-hr. or 12 per cent per 1000 operating hours.

Even though the savings in driving power do not quite compensate for the higher cost of roller bearings, there are other advantages obtained for grates with spring tension, such as longer wear of the grate drums and bearings. Time for overhauling is also much less.

Grates which have stationary tension in front, are equipped with roller bearings only at the rear end. Larger roller bearings and stronger boxes would increase the durability of roller bearings so they could resist the hard knocks of stationary tension.

*Abstracted and translated from Archiv. fuer Waermewirtschaft.

Improved Trash Boom Design

In the operation of hydroelectric generating stations a well designed trash boom is a necessary part of equipment and in the case of even moderate sized stations the cost of such a boom will run well above $10,000. In these days when first class lumber is difficult to secure, we find that the main timbers in our trash booms had to be renewed about every 4 yr. Investigations developed the fact that the point of decay is always on the top side and in a V shaped section indicated by the shaded area in Fig. 1.

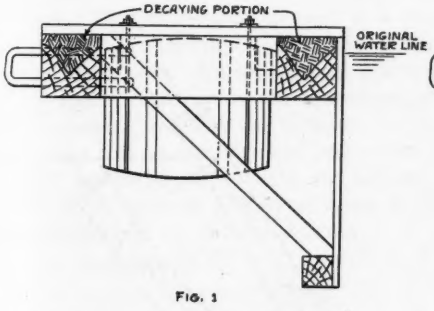


FIG. 1. ORIGINAL CROSS-SECTION OF BOOM BETWEEN CROSS BRACING. SHADED AREA INDICATES POINT OF DECAY

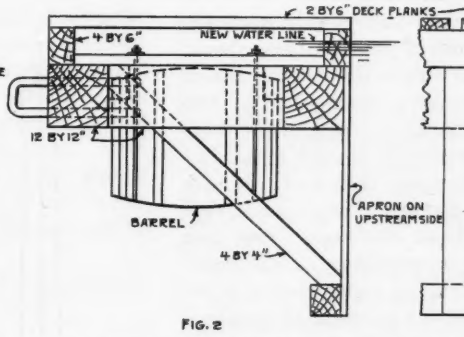


FIG. 2. NEW DESIGN WHICH SUBMERGED THE MAIN TIMBERS FROM 4 TO 5 IN. AND PROVIDED DECK PLANKING AS SAFEGUARD AGAINST PROJECTING ROD ENDS

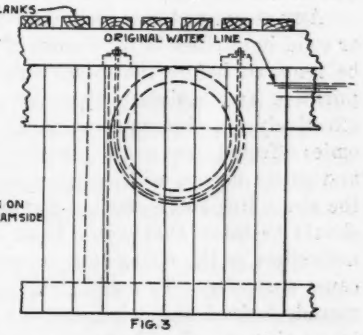


FIG. 3. SIDE VIEW OF NEW DESIGN SHOWING HOW DECK PLANKS ARE LAID

It has been our experience in renewing the heavy head gate timbers that those which were completely submerged were always found to be in a sound condition regardless of the number of years in use, and those at the water line subjected to the combined action of air and water were always decayed and rotted out. This led us to believe that the same reason might apply to our trash boom timbers.

In the original method of construction, which is illustrated in Fig. 1, the original water line was about 3 or 4 in. below the top of the main 12 by 12 timber. Figure 2 indicates changes made which enabled us to submerge the main timbers completely and still obtain a comparatively dry walk way and free from the hazard of projecting ends of barrel supporting rods; Fig. 3 shows side view.

This improved method has been in use about 6 yr. and it can be safely stated that the life of the boom has been more than doubled. It is evident that the parts which will need renewing in the future are the 4 by 6 deck supports and 2 by 6 decking planks and this can be done at little cost. The main body of the boom bids fair to last many years longer than formerly.

Columbus, Ga. J. Jacobs.

Steam Meters

In any steam power plant reliable steam meters are a necessity if economical results are desired, since this is the only possible way to keep a check on the quantity of steam used. Venturi meters are largely used for this work and, provided they are of a good make, correct size and properly installed, their indications are reliable as to the amount of steam used. They must be so installed that the steam flows through the meter in the direction of the arrow marked on the meter. Care must be taken to see that the packing at the inlet side, where the meter is connected to the steam pipe, does not project inside and, if possible, the connection to the meter should be arranged so as to cause no alteration in flow until the steam enters the Venturi tube. Steam eddies in the pipe, such as might be caused by neighboring bends, steam traps or unevenness in the pipe line adjacent to the meter, would cause inaccuracy in the meter reading; these should be avoided and a straight length of pipe, the length of which is at least five times its own diameter, should be inserted in front of the Venturi pipe. Some meters are set horizontally and some vertically and care should be taken that they are fixed true in their respective positions. They should be subjected to the minimum amount of vibration possible. Accumulation of dirt, rust, scale, etc., in the throat of the Venturi tube and connecting pipes decreases the effective area and increases the velocity of the steam, thus causing the meter to register higher. Moisture and impurities also cause inaccuracies.

Another meter is the vane wheel meter. This type was used in the early days but, owing to many operating difficulties, it was practically discarded. These difficulties, which were due to dirt in the steam, wear in the bearings and steam leakage through and friction in the

glands, have been overcome in a modern meter now made. The wear on the rotor bearings of this meter is kept to a minimum by making the bearings of an especially hard material. These bearings are easily replaceable and will run for some 18 months without undue wear. The normal steam flow is upwards and the pressure on the rotor due to this is just balanced by its weight, so the rotor virtually floats in its bearings, thus practically eliminating wear and friction. The actual speed of the rotor is kept low by fitting it with damping vanes which run in water condensed from the steam. Derangement through impurities in the steam is avoided by putting the rotor in a shunt circuit, so that any dirt, etc., in the steam blows straight through the meter.

Gland leakage and friction which previously caused inaccuracies have been eliminated by driving the counter mechanism through an especially designed magnetic gland. The counter mechanism is in an air-tight chamber and is completely protected from any disturbing influence. These meters are very accurate and are undamaged by and register accurately on considerable overloads. They will meter down to 1/10 of the maximum full load flow and still maintain their accuracy. The initial accuracy is well maintained in service.

Any steam meter is likely to be affected by moisture or solid impurities in the steam; if possible, these should be removed before the steam enters the meter. Steam purifiers and moisture separators which will do this effectively are obtainable at no great cost and the economies effected, due to the pure steam in both steam line and prime mover, will amply repay their cost. If ever the steam line and meter are put out of commission, care should be taken that water from condensed steam does not collect in the meter or its connections, as this would cause corrosion. To avoid this, the meter should be removed, drained and dried, and the connections examined to see they are clear before reconnecting.

Brentford, England. W. E. WARNER.

Is the Small Factory Doomed?

I HAVE just finished reading the editorial entitled "Is the Small Factory Doomed?" published in your January 15 issue. I have also read the article by Thomas N. Carver in the Nation's Business, referred to in the editorial.

I think that Mr. Carver has missed one important avenue of usefulness which the small factory can fill. He states that, in large scale production, motions are saved in changing from one line of work to another, in laying down one tool and picking up another, and so on. It is true that, in a large factory, mass production and consequent reduction in cost per unit are obtained because machines are set for one kind of product and the finished article pours out like meat from a meat chopper.

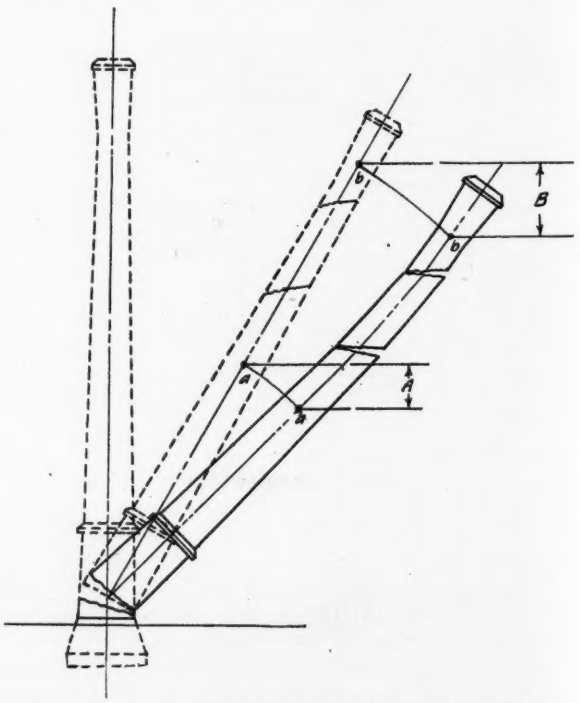
If one article has to be changed to fit the demands of one particular customer, it tends to disrupt or derange, consequently slowing up the production of the whole. This is because the special product requires special attention on the part of the designer to make sure that all special features are incorporated in the design, special attention on the part of the production man to make sure that unusual delays do not occur and special attention on the part of the factory operators who have to see that the product receives the special operations demanded by its peculiar design.

In the case of the small producer, it often happens that even if the chief designer does not also have the functions of the production department, he is at least in close touch with the production department and it is comparatively easy for him to care for the varying requirements of different customers. There are many firms in the market for certain lines of finished products; at first glance it might seem that identically the same products would meet all their requirements. A closer analysis of their requirements, however, will show that the peculiar requirements of each of these buyers require special attention on the part of the manufacturer. Right there the small factory will have a chance to shine.

Schenectady, N. Y. E. F. ROGERS.

Why Falling Chimneys Break During Descent

BRICK CHIMNEYS, in falling, fracture into several pieces in a manner that has impressed some people as paradoxical. When reaching an angle somewhat more



CHARACTERISTIC RUPTURES IN FALLING BRICK STACKS ARE DUE TO COMBINATION OF FORCES

than 30 deg. from the vertical, diagonal cracks appear; at about 45 deg., the chimney has broken into two or more pieces, with the upper surface bent upward as though the outer end were impeded by an external resistance of some kind. One explanation of the upward curve of the chimney is the resistance offered by the air, an idea which may be dismissed because the fractures appear in the chimney when its velocity is slight compared with that necessary to cause rupture by wind pressure. The fractures are the characteristic shear, or diagonal-tension kind, common to tests of beams.

In its movement downward, the chimney is subjected to centrifugal force by reason of the constantly changing direction of its particles, and to the pressure of the air by reason of the rapidly increasing velocity of fall. Both these forces increase with the descent and aid, although slightly, in the transverse rupture of the chimney.

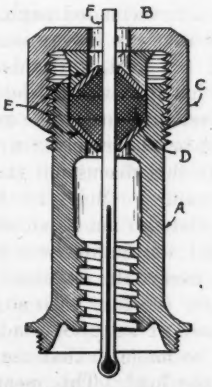
In the figure the chimney is shown falling from the position of the dotted lines to the position of the full lines. Points on the chimney describe arcs a-a and b-b, the respective vertical distances being A and B. Under the action of gravity the point a moves through the vertical distance A, as should also the point b. But b actually moves through the vertical distance B, which longer travel can only be attained through an accelerating force added to that of gravity: This force is found in the great weight of the lower portion of the chimney transmitted lever-wise through its length. The force of acceleration is sufficient to produce transverse stresses in the chimney that the brickwork is not capable of withstanding, so the chimney is fractured in its descent.

An idea of the forces existing in a falling chimney may be had by means of a pole that can be conveniently handled. Balance the pole vertically in the palm of the hand and allow it to fall until the far end strikes the ground. The velocity of descent is a resultant of the tendencies to varying accelerations throughout the length of the pole. Unless the pole is very slender, there is no visible evidence of the transverse stresses caused by increasing acceleration toward the far end. Now, grasp the pole at the butt end and cause the far end to fall at an increased velocity by torsion of the wrist. The torsion causes a transverse stress in the pole analogous to that in the falling chimney.

Los Angeles, Calif. C. O. SANDSTROM.

Bonnet Serves as Thermometer Support

OLD VALVE parts frequently thrown into the scrap heap could be used conveniently on bearings that have round holes, as shown in the illustration.



VALVE BONNET FROM SCRAP HEAP AND TWO CUPPED WASHERS FORM EXCELLENT SUPPORT FOR BEARING THERMOMETER

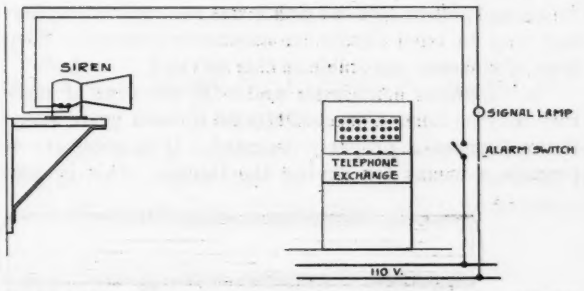
A—Bonnet from old globe valve.
B—Packing gland.
C—Packing nut.
D—Rope asbestos packing.
E—Cupped washers.
F—Thermometer.

With this arrangement, a thermometer can be held at a safe distance, say at least $\frac{1}{16}$ in. from the oil ring on a bearing, thus making it possible to know the exact temperature of such a bearing at any time. It also serves as a check on a recording thermometer connected to the feedwater line when it is similarly attached to that line.

Chicago, Ill. CARL L. RIDDER.

Pilot Lamp Aids Operator

AFTER ORGANIZING a mill fire brigade, it became necessary to provide means for conveying signals to the different departments where the brigade members were employed. The plant telephone exchange operator was the logical person to operate the alarm and electric sirens were chosen as the means of conveying the alarm. Due to the great number of buildings and floors, the signals had to be made by combinations of short and long blasts from the sirens.



ELECTRIC LAMP AIDS IN INDICATING PROPER TIMING OF ALARM BLASTS

One of the difficulties encountered was the inability of some of the telephone operators to distinguish sufficiently between the short and long blasts. A signal lamp placed just above the alarm switch helped to solve the difficulty. By watching the signal lamp, they are enabled to more clearly distinguish between the different signals. The illustration shows the plan used.

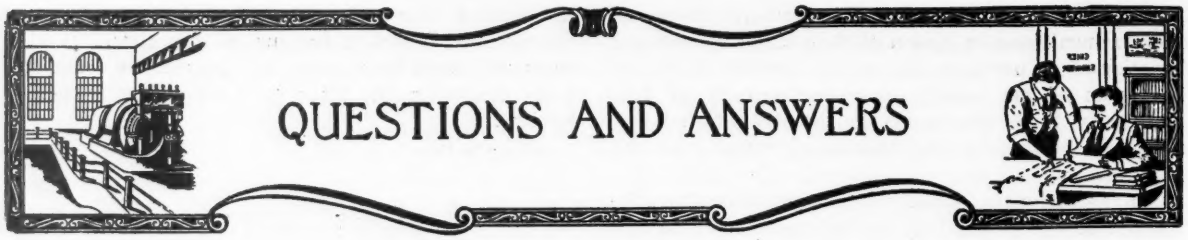
Moline, Ill. ROBERT ALTHAUS.

Wire Solder Has Many Uses

A SPOOL of wire solder is a good thing to have at hand in any power plant. It can be used for several purposes for which it was not intended. A turn or two put into the bottom of pump valve rod packing boxes with the packing on top of the solder and then a few turns more of the solder on top of the packing will often prove a big help in converting a troublesome box into a docile one. Similar procedure may be used in packing fairly large globe valve packing boxes.

Where the steam pressure does not exceed 150 lb., it has been successfully used on flanged joints and cylinder heads, replacing copper wire. In the latter case, tightening up the bolt nuts from time to time is required. Some round packings have a small hole through the center; solder wire pushed through this hole converts the packing into a combination packing that will seldom blow out if care is used to flatten or file the ends so that they will overlap each other for about $\frac{3}{8}$ in.

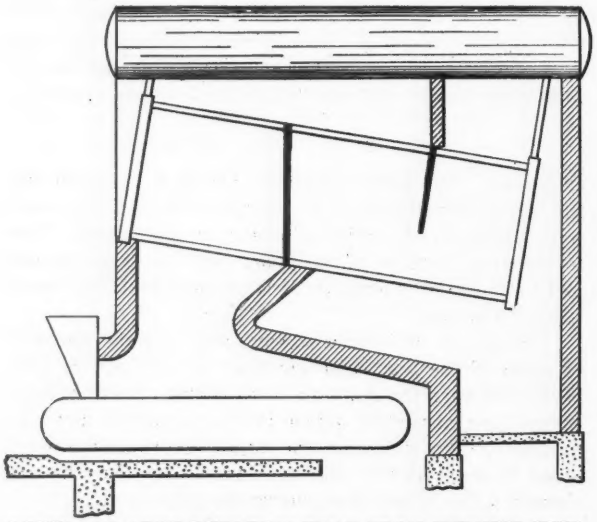
Hollyburn, British Columbia. JAMES E. NOBLE.



Lignite Can Be Burned on a Stoker

IN OUR DISTRICT is a municipal power plant in which the attempt to burn lignite on inclined grate stokers failed and return to hand firing was resorted to. Is there any way to burn lignite on automatic stokers? What type of stoker is adaptable to this service? J. T.

A. Lignites containing under 35 per cent of moisture may be burned successfully on a chain grate stoker if the furnace is properly designed. It is necessary to provide a means for drying the lignite. This is done



REVERSED ARCH REFLECTS HEAT FROM BURNING FUEL UPON FRESH LIGNITE, DRYING IT IN PREPARATION OF COMBUSTION.

by reversing the usual arch design by extending a roof over the furnace from the rear, as shown in illustration. The roof should not be high above the grate so that the hot gases coming from the fuel, which is burning on the rear end of the grate, will heat and dry the fresh lignite entering the furnace at the front end of the grate. The fuel is fed into the hopper in the usual manner.

Points to be considered in combustion are:

1. Lignites containing up to 35 per cent of moisture can be burned at combustion rates of 30 lb. per sq. ft. of grate per hr.
2. Sub-bituminous coals containing 23 per cent of moisture have been burned at 50 lb. per sq. ft. of grate per hr.
3. Lignites containing over 35 per cent of moisture have not been successfully burned commercially on grates.
4. Air preheaters offer large opportunities with all high moisture coals.
5. Large grate areas must be provided.
6. Large furnaces and liberal arches must be provided.
7. Forced draft should increase combustion rates.

Steam Plant Operation

MY CONTRIBUTION, published on page 365 of the March 15 issue, did not take into consideration the possibility of an engine carrying a continuously fluctuating load such as is found in rolling mills. Mr. Brown's letter on page 430, therefore, prompts me to add further comments.

The compound engine—particularly one with four valves and double eccentrics, such as the Corliss type—lends itself to making any kind of valve adjustment that may be desired, in order to obtain a certain steam distribution in the engine as a whole. Compound engines are designed to carry a limited range of load economically. While the engine can, and often has to carry overloads, it can do so only at the expense of economy. Overloads call for a different adjustment of the valves and steam distribution than that which obtains in an engine carrying a load within the economical range. The same thing applies, relatively, in the case of an underloaded engine. New adjustments should be made. Let us briefly consider these three conditions: A properly loaded compound engine, an overloaded compound engine and an underloaded compound engine. With the properly loaded engine, the adjustments should be made so that either both cylinders should carry an equal share of the load, or that the initial stresses on the parts in both cylinders should be equal or nearly so.

In the case of an overloaded engine, the adjustments should be made so that the low-pressure cylinder carries a greater part of the load, and this means shortening the cutoff in the low-pressure cylinder and thereby increasing the receiver pressure. The greater the overload the higher should be the receiver pressure. (It is assumed throughout this discussion that the boiler pressure is a fixed value.) Such an adjustment of the valves and steam distribution is not economical from the standpoint of what the engine was originally designed for, but it will carry the overload without "laying down", as would be the case with adjustment.

Now, in the case of an underloaded engine, the adjustments should be made so that the high-pressure cylinder carries all the load. This means lengthening the low-pressure cutoff and reducing the receiver pressure, so that the low-pressure piston is merely moving back and forth as a drag on the high-pressure engine. While this seems unnatural and drastic treatment to give to an engine, it is better than having it "slapping around" and not nearly living up to the load, as we say. Of course, I have been considering the extremes of over and

underloads, in order to emphasize the idea of making adjustments, and of having the steam distribution to suit the condition.

But, with an engine as cited by Mr. Brown, where the load is frequently changing from one extreme to the other, and that is the natural and expected condition of operation, then the adjustments should be made so that the heaviest loads can be carried and the other loads carried as best they can.

The auxiliary receiver and trap arrangement illustrated in Mr. Brown's letter is a good idea and will take care of the situation as far as danger from condensation is concerned.

Brooklyn, N. Y. CHARLES J. MASON.

Negative Lap and Boiler Construction

KINDLY let me know the following:

1. When and why is negative lap used on Corliss engines?

2. Is the pressure on the nipples of the mud drum of a Babcock & Wilcox boiler the same when the pressure is off as when it is on?

3. Do the water legs of a Heine boiler tend to spring apart?

4. What is the mean diameter of a hollow stay bolt?

5. Why do the through stays on a horizontal return tubular boiler bow up?

6. Is there any difference in the pressure on flat and dished shape boiler heads? C. L. P.

A. Nearly all single eccentric, Corliss valve gears and some double eccentric gears are of the, so-called, half-stroke type, in which the steam valves usually have positive lap, with wristplate central. Maximum cutoff about four-tenths stroke. To increase the range of cutoff the steam valves are sometimes given negative lap, the eccentric being retarded in proportion.

With the long range gear having a maximum cutoff of three-fourths stroke, the steam levers travel right with the rocker arm so that with the latter in central position, the steam valves are half open. A steam wristplate need not be used. With this type of gear it is necessary to have the steam hooks trip, each stroke, regardless of the position of the governor. The exhaust valves always have some positive lap and are treated the same in half stroke gears as in long range.

2. The internal pressure on the nipples of the mud drum of a Babcock & Wilcox boiler, when it is properly filled with water but is cold, is due to the static head of the water, i.e., the pressure corresponding to the height of the water level above the nipple.

When the boiler is under pressure, the internal pressure on the nipple is equal to the steam pressure plus that corresponding to the static head of the water.

3. The water-legs of a Heine boiler form rectangular boxes. They have flanged semi-circular throats to provide for the riveted connections with the drum or drums. The tube and manhole sheets of each water-leg are tied together with hollow stay-bolts. Therefore, although the water-legs tend to spring apart when under normal pressure, they are so reinforced that they are not permitted to do so.

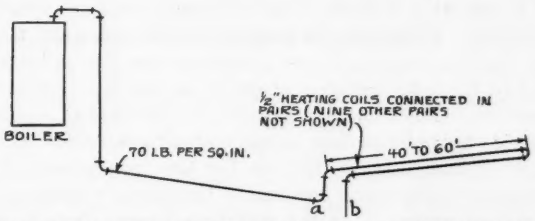
4. Your question, no doubt, has reference to the cross sectional area of a hollow stay bolt and, therefore, what is required is not the "mean diameter of the bolt," which is merely its average diameter, but the diameter of the mean fibre section, i.e., the average of the outer and inner diameters, which is found by adding these two diameters together and dividing by two.

5. All through stays when installed are intended to be perfectly straight, but due to expansion and contraction of other parts of the boiler, they may become bowed up. If the fire sheet bulges out due to heat, as it frequently does, the lower part of the front head is pulled inwardly, causing the through stays to be bowed away from the fire sheet.

6. The total pressure on the heads of a boiler drum is the same whether it is flat or dished. The reason for dishing the head is not to avoid pressure but to make it stronger so as better to withstand pressure.

Traps Must Be Properly Placed in Heating System

AS SHOWN in the sketch, the steam outlet of our heating boiler is higher than the heating coils. In order to keep the system free of condensate, will it be necessary



LOWER POINTS OF EACH COIL MAY BE DRAINED BY SINGLE TRAP BUT DEAD END HEATING LINES MAY BETTER BE EMPLOYED

to use two steam traps, one at "a" and another at "b" or will one be sufficient by connecting "a" and "b"? E. M. D.

A. Drains from the two lines could be combined at "a" and "b" and lead to a trap in common, without giving trouble, if, of course, an air valve has been installed at the higher end. Under the conditions stated, there appears to be no need whatever for the line "b." If air valves are placed at all high points, a number of lines could be made to extend out from "a" and dead end, the return condensation flowing back along the bottom of the pipes just as is regularly done in one-pipe heating systems.

Shavings and Sawdust as Fuel

REFERRING to the question regarding effect of excess air on refuse wood burning asked by L. P. on page 430 of the April 1 issue, the reserve air may be very effectually kept out and the fuel properly fed by the use of an automatically controlled screw feed with paddle wheel feeder such as was described in detail on page 873 of the August 15, 1927, issue.

For this class of fuel, the furnace should not be of the regular flat grate type, as much better results are obtained by dropping the fuel on the upper end of stationary inclined grates and allowing it to drift down to keep the lower end of the grates thoroughly covered. Of course, the proper method of handling the fuel at the lower end should be provided.

EDITORIAL COMMENT

Mechanical Aids to the Solution of Engineering Problems

Models have been used with considerable success in many branches of engineering for predicting performance characteristics of future projects. In naval architecture, for instance, small ship models are usually constructed and the design of large ships based upon their performance. Similarly, in hydraulic turbine design, small models of runners have been used in the same manner. Such models are true models, since, except for size, they are exact likenesses of the full sized projects.

Our attention has been concerned lately with models of a somewhat different type, although used for similar purposes. These are the mechanical and electrical models used in the calculation of transmission line constants and in the determination of electrical machinery characteristics. Continual development in the field of electric power transmission has brought about conditions which make it increasingly difficult for the transmission line engineer to calculate accurately the characteristics of a proposed system. As the distances become longer and the amounts of power to be transmitted become larger, the equations involved in the solution of transmission problems become exceedingly complex, in fact, accurate calculation becomes impossible in many cases. So the transmission engineer is resorting to the use of mechanical models. In 1926, C. F. Wagner of the Westinghouse Co. built a mechanical model of a transmission system for the purpose of demonstrating stability phenomena and this has proved so successful that it is now being used in the actual determination of transmission line characteristics. This model consists essentially of a system of levers and pulleys with springs, which can be adjusted to represent various conditions of voltage, reactance, excitation, etc. Normally such a system is balanced. When the required adjustments are made, the balance is disturbed and the system undergoes oscillations which simulate the electrical oscillations in the actual transmission system. Models of this type have actually been used in the design of the Conowingo transmission system.

Of a similar nature are the kinematic models constructed by Prof. Karapetoff for studying the characteristics of various kinds of rotating electrical machinery. There are virtually mechanical vector diagrams, which automatically show the effect of varying one or more of the various electrical constants.

Another type of model, different in principle from those discussed but having similar application, is the short circuit calculating table used by electric power companies. In these tables a number of resistances and sources of current are arranged so that the actual conditions of any network of distribution lines may be simulated and by means of an ammeter the actual short circuit current at any point on the system easily determined. It is of interest to learn that one company has been using a table of this kind for determining the size of new conductors to be installed in the system.

A more complicated machine than any of those mentioned is a machine said to be at Harvard University which will solve mechanically any triple differential equation put to it. In a few hours or half a day this machine will solve mathematical problems which would require days or even weeks by direct calculation.

Many other interesting examples could be cited but these few will suffice to indicate the possibilities of devices of this kind. They are of considerable interest and their use will no doubt be extended to many other fields. Of course, we don't expect that they will completely displace all professors of mathematics and we wouldn't go so far as to say that this would be desirable, for even a professor of mathematics is of some use, contrary to the opinion of most practical men. If for nothing else, we would always need a few of the species to design these machines.

Use the Fuel That Makes the Cheapest Steam

In the burning of any fuel to make steam, regardless of what that steam is finally to be used for, the criterion of results is—or should be—the cost of steam. In some cases, a comparatively expensive fuel will give the lowest cost of steam per thousand pounds; in other cases a comparatively cheap fuel will give the lowest steam cost.

This cost includes fixed charges and operating charges and it can be seen that the various components of these will vary in different plants. Hence actual tests in the plant under operating conditions for a period of a month or so are of greatest value in determining the coal to be burned to give lowest steam cost.

These ideas were forcefully presented by T. A. Marsh at the recent Indiana Fuel Conference at Purdue in a paper on Fitting the Fuel to the Plant, noted elsewhere in this issue. In the discussion of this paper, they were reiterated and commended by other speakers and a further interesting idea was brought out.

Certain plants have found that while their normal load can be carried with entire satisfaction with a low-priced coal and one not of the highest grade obtainable, their peak load necessitates either the operation of another boiler or the use of a higher grade of fuel that can be burned in larger quantities in the same furnaces without increasing the furnace maintenance unduly. Thus, if the peak load does not occur often—possibly two or three times a year in some types of industrial plants—and if the peak is not too high in comparison with the normal, it will pay to keep in storage a small amount

of the highest grade coal obtainable, to use only for such peak loads. This, it was pointed out, is actually being done by certain plants.

It has the effect of preventing an increase in cost of steam even though the higher grade fuel itself is more expensive. This is because maintenance cost does not go up in proportion; capital costs of the investment in stored coal do not increase unduly; in short, the plant may obtain, let us say, 30 per cent more steam for a short period with the higher grade fuel at only a slight increase in cost per thousand pounds, which is the important cost. That slight additional cost may be justified to meet a demand that could not be easily met in any other way.

As Mr. Marsh succinctly stated it, the guiding principle is: Use the fuel that makes the cheapest steam. It may be a low-priced, low-grade fuel; it may be a high-priced, high-grade fuel; it may be a combination of cheap fuel for one load condition and a more expensive one for another load condition. The latter idea seems to be somewhat new to many engineers. But it follows the principle that cost of steam, not boiler efficiency, is the important thing in burning coal.

The Power Plant as a Service

Ordinarily the outsider thinks of the power plant as beginning at the coal pile and ending where the steam pipes or transmission lines leave the power plant building. In a material way this is correct and yet in the broader sense of the word it does not meet the modern engineer's definition.

Years ago when the chief engineer was a member of the greasy overall fraternity, lord of a department considered too technical and beneath the dignity of the manager to even attempt supervision, the goat in case of power supply failure regardless of the cause or a person to be forgotten when everything ran smoothly, the power plant did indeed consist of the four walls housing a small industrial unit beyond the pale.

Gradually, however, keen industrial competition and the phenomenal increase in the use of machines aided and abetted by the accountant, statistician, efficiency expert and engineer, have increased the importance of the power plant until today, aping business phraseology, it is a service rather than a department. Everybody in the organization from the president down is directly affected by some phase or phases of this service which includes heating, ventilation, process steam, electric power and lighting.

Proper administration of this important service is essential if competition is to be met and proper administration involves the cooperation of the management, engineer and manufacturer. Each has his part to do and to do this part successfully, it is necessary that each recognize certain definite relations to each other.

The management is responsible for keeping the growth of the power plant in pace with the growth of the production departments, the power costs in relation to factory output and satisfactory working conditions for the men under him.

For the more technical details, he must depend upon the engineer who is in turn responsible for making the best use of the available equipment, insuring continuous operation, keeping in touch with new developments and studying the possibilities of his plant. Above all he should speak the language of the management so as to be able to give a summary of operating results, utilization of equipment, limitations of the plant and operating variables.

Then the manufacturer has his part to play. He should, first of all, sell only equipment that is suited to the job and for which there is a need. After this he must keep in touch with the equipment to see that the operators know how to take care of and operate it properly and get the maximum out of it.

Although the cooperation of all three is necessary, the engineer in the final analysis is the keystone upon whom the other two must depend. If the engineer knows the individual pieces of equipment, their capacity and performance both in relation to similar equipment and theoretical performance as well as the part they play in the operation of the station as a whole, the power plant will more or less take care of itself.

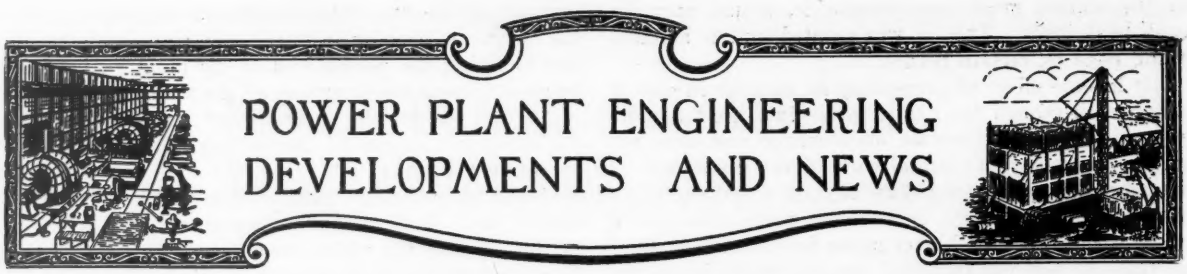
Not, of course, because even the best plant can run without direction, but because in getting this information the engineer must of necessity become intimately acquainted with the plant and conditions of operation. If he has not the ability to take advantage of the information, the plant stands still or slips backward and a new engineer appears on the scene.

No set standard of performance or solution of the general problem of power plant performance and betterment can be made. It is a question of breaking up the complex whole into its component parts, isolating each and studying its operating and limiting condition, its operators, performance and means of betterment and then looking at the reassembled information in its entirety not alone from the standpoint of the power plant but from the standpoint of departments which are to be served. The life and utility of the industrial power plant depends on the service it renders to other departments.

SIMPLE TESTS to compare the slacking tendencies of coal have been in progress in the laboratory of the Pittsburgh Experiment Station of the United States Bureau of Mines. The relative tendency of bituminous coals, particularly those of the lower ranks, to slack, has long been observed and has come to be regarded as indicative of the rank to which a coal belongs.

Furthermore, the more readily a coal slacks, the greater is its tendency to heat spontaneously and, in general, the poorer are its storage qualities. No laboratory test for comparing the slacking tendencies has heretofore existed and the simple test developed should be of interest.

It consists in air-drying the coal sample for 24 hr., immersing it in water for 1 hr. and then air-drying again. This alternate drying and wetting exhausts and fills the pores of the coal, causing internal strains leading to slacking. The process is, in effect, accelerated weathering, the amount of fines produced for a given coal being a measure of its tendency to slack or weather. The test, although admittedly rough, will serve for purposes of comparison and should be of considerable value in the classification of the lower rank coals.



Indiana Fuel Conference Meets at Purdue

ENGINEERS, FUEL PRODUCERS AND OTHERS INTERESTED DISCUSS INDIANA'S FUEL RESOURCES AND METHODS OF UTILIZING THEM IN CONFERENCE AT PURDUE UNIVERSITY, LAFAYETTE, IND., APRIL 5 AND 6

METHODS OF BURNING, storing and merchandising Indiana fuels were discussed at the First Indiana Fuel Conference, held April 5 and 6 at Purdue University, Lafayette, Ind., under the direction of the School of Mechanical Engineering and Engineering Extension Department, with the School of Chemical Engineering co-operating. The total registration was 104, composed of operating engineers in both central station and industrial power plants, purchasing agents, coal operators and salesmen, consulting engineers and members of the faculty of Purdue University.

On Thursday, April 5, at 1:30 p. m., Professor W. A. Knapp of the Engineering Extension Dept. presiding, the conference opened with an address of welcome by G. A. Young, head of the School of Mechanical Engineering, who outlined the objects of the conference and the work of Purdue in serving the industries of the state of Indiana and of the nation. Explanation of the extent and characteristics of fuel resources of Indiana, including coal, natural gas and oil, was given by W. N. Logan, state geologist. This was followed by a discussion of Fuel and Power as Affecting Progress by A. A. Potter, Dean of Engineering, Purdue University. Dean Potter emphasized the fact that our present civilization is the first that is not based on slave labor, which has been replaced by electric power resulting from the burning of fuel. R. B. Moore, Dean of the School of Science, called attention to the vital interest of the modern chemist in the process of combustion, which is a chemical process and is the chief interest of the modern power plant engineer. Of great importance to the power plant engineer is the research work with fuels now being carried on, not by engineers but by chemists. This includes the work of Bergius and others in obtaining liquid fuels from coal, the various processes for obtaining by-products from coal, leaving high grade coke to be burned in furnaces and the researches into production and utilization of fuel oil.

TREND OF POWER DEVELOPMENT REVIEWED

Following the first afternoon session, a dinner was held in the new Memorial building of the University. At this dinner Dean Potter acted as toastmaster and the speaker of the evening was A. D. Bailey, Superintendent of Generating Stations, Commonwealth Edison Co., Chicago, who spoke on The Trend of Power Development. Mr. Bailey reviewed the development of the electric power industry, calling attention to the increasing demand from the consumer for perfection of service for hundreds of applications, whether this service is to operate a small electric clock or a large motor of several thousand horsepower. He also referred to the confidence on the part of the public in the electric utilities, which have avoided many of the pitfalls that proved so disastrous to other utilities such as the railroads. Superpower is only a catch-word for inter-connection, Mr. Bailey explained, which has been carried out by engineers for a long time. Our present inter-connections seem to be leading to a decentralization of industry, as they allow us to bring power to the work instead of locating our industry near the power supply.

FRIDAY MORNING SESSION

Friday morning's session, of which H. C. Peffer, head of the School of Chemical Engineering, was chairman, opened with a symposium on Burning Indiana Coal. The first paper, by H. C. Carroll, Director Combustion Engineering Department, Commercial Testing and Engineering Co., Chicago, took up fundamental problems in burning Indiana coal commercially. Typical analysis of No. 5 seam Indiana coal as received shows: moisture, 9.94 per cent; ash, 12.55 per cent; volatile, 37.41; fixed carbon, 40.10 per cent; B.t.u., 11,164; sulphur, 4.31 per cent. After a discussion of the various coals and the equipment available for burning them, Mr. Carroll took up seven factors that should be considered in fitting coal burning equipment to an existing plant or to a new plant. First, availability and kinds of coal tributary to the plant should be studied, so that the cheaper and more abundant coal available can be utilized. Second, the character of the load has great influence on selection of boilers and firing equipment. Third, available draft is of importance, involving more care in breeching design than is usual. Fourth, proper combustion space must be provided and fifth, baffle arrangements merit attention. Sixth, rating and size of boilers, steam pressure and temperature are factors that influence investment costs. Seventh, proper instruments are needed to produce the records needed for maintenance of best performance and determination of costs. Mr. Carroll also showed lantern slides of various types of grates, mechanical stokers and pulverized coal equipment in actual installations using Indiana coal.

In discussing this paper, Mr. Marsh stated that, in

many cases, the horizontal return tubular boiler, if set 6 ft. high, provided a good combustion space for the application of pulverized coal equipment such a space being comparatively large for the heating surface of the boiler. He also called attention to the abandonment of coal dryers in favor of mill air, the temperature of which is usually kept below 400 deg. F. for safety.

Domestic Use of Indiana Coal

Burning of Indiana Coal Domestically was the subject of an interesting talk by C. H. B. Hotchkiss, assistant professor of Heating and Ventilating at Purdue. Professor Hotchkiss pointed out that although coal is the principal domestic fuel, it is used domestically to produce home comfort rather than to secure economy. The housewife has the largest influence in its selection and often has to fire it herself and the first thing she thinks of is convenience and cleanliness, hence the popularity of oil and gas for domestic use. Coal producers and engineers must develop and advocate use of coal burning equipment that can compete on the basis of cleanliness and convenience with oil and gas, if they wish to keep their domestic markets. New methods of house construction and insulation and new heating systems may result in coal economy in the home, but if means can be found to burn the lower grades of coal in a clean and convenient way, this will leave more of the better grades for industry. Little attention has been paid so far to design of boilers or furnaces for domestic coal. Whatever is done, however, must be based on convenience and comfort rather than on cost.

In discussion, Mr. Ray suggested use of pulverized coal for domestic use, prepared in a central plant; Mr. Carroll stated that this is being done in a large city in Indiana, the pulverized coal being delivered by tank wagons. The costs of preparation and delivery, however, are high. Mr. Marsh stated that his company expects the low temperature carbonization process to yield good coke and possibly gas for domestic use and suggested use of Indiana coal in this way. Attention was called to several domestic stokers now on the market.

Storage of Coal

A. J. Hoskin, Research Associate of the Engineering Experiment Station at Purdue gave the next paper on Coal Storage. Factors tending to produce spontaneous combustion of coal in storage, he said, are oxidation of the coal itself, presence of sulphur, inherent gases such as methane or CO_2 produced by coal and air, this CO_2 in turn dissolving in the coal with evolution of heat; moisture is also a frequent cause. Segregation may cause fires, while substances such as waste, paper, wood, weeds, coal from former storage, may act as kindling. Storage ground should, therefore, be thoroughly cleaned before use and should slope to give drainage. To expel air from the pile, several interesting methods are used. At one central station, the bucket crane dumps the coal in mounds over the storage space. Then a 5 t. weight is dropped on each mound to flatten it and expel air. At another plant coal is first spread in a layer 17 in. thick by a drag scraper, then rolled to 13 in. thick. This expels air, squeezes fines into the coarse coal, makes the surface dense and keeps air out. The process is repeated to the required height.

In the next paper on storing of Indiana screenings, further emphasis was given to the above points by citation of many examples of coal storage conditions by M. A. Tuttle, Combustion Engineer, Knox Consolidated Coal Co., Indianapolis, Ind. He gave four determining factors in storing these screenings: 1. foundation of the pile; 2, depth of pile; 3. segregation of fines; 4. firmness of pile. Pictures were shown first of a coal pile stored on ground that sloped; this pile went through last summer with a maximum temperature of 156 deg. F. Coal piles put down on former weed patches were shown; these fired within 30 days after storing.

Coal pile 7 ft. deep showed temperatures as follows:

Feet of depth....	1	2	3	4	5	6	7
Temp., deg. F....	121	138	144	142	134	120	106

Apparently the earth was conducting heat away faster than the air.

A 12-ft. pile, put down in December, 1926, showed the following on Jan. 15, 1927:

Feet of depth.....	4	6	8	10	12
Temp. deg. F.....	154	160	162	166	158

These temperatures have been increasing 10 deg. a week and the pile had to be moved. As it had been put down in an excellent manner, it was evidently too deep to radiate the heat generated.

Lack of firmness of the pile in many cases was shown to be the cause of fires. Trucks which run over the pile to dump coal on it pack it firmly; dragging of coal, or the methods mentioned by Mr. Hoskin, were all recommended to prevent segregation and keep out air and moisture.

Friday Afternoon Session

On Friday afternoon, the third session of the conference was held, at which Professor G. A. Young presided, A. W. Cole, Professor of Steam Engineering at Purdue, discussed the causes of smoke, losses caused by it and methods of preventing it, especially in domestic installations.

Following this was a paper on Fitting the Coal to the Plant by T. A. Marsh, Consulting Engineer, Combustion Engineering Corp., Chicago. Mr. Marsh stated that plants should, of course, be designed to burn the fuels most readily available. When this condition has to be reversed, as is often the case, the guiding principle is: Use the coal that makes the cheapest steam. To determine this by actual tests of 30 days or more under operating conditions right in the plant, sufficient instruments are needed to determine costs per thousand pounds of steam. Items influencing selection of coal are: ability to carry plant load; reliability of supply; mine equipment (ability to supply certain grades and sizes); mine preparation; ability of producer to give uniform quality; transportation facilities; adaptability to stoking equipment (installed or contemplated); service (engineering assistance from coal company); storage properties of coal; boiler capacity obtainable; maintenance costs of furnaces and stokers; fusion temperature of the ash; labor of firing; responsiveness to meet sudden load demands; smokelessness (furnace design a factor); cost of ash removal; sulphur content.

Sometimes the most expensive coal produces the cheapest steam, while in other cases a cheaper coal gives the cheapest steam even though the plant efficiency may be lower. The determining factor is dollar economy, not efficiency.

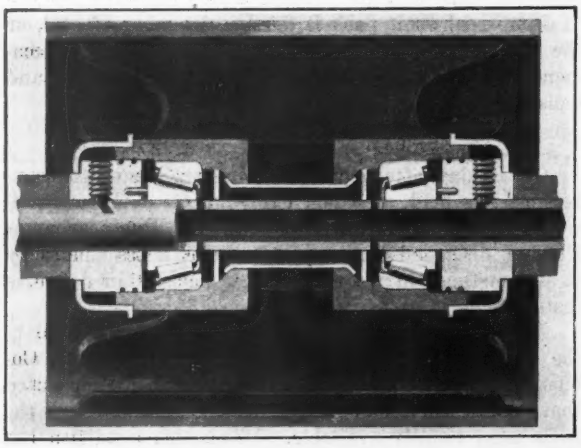
In discussion of this paper, it was brought out that it may sometimes reduce investment costs and coal storage charges to have a high grade coal available in smaller amounts to handle peak loads, as is done in some plants.

In the final paper of the conference, H. A. Glover, Vice President, Knox Consolidated Coal Co., Indianapolis, discussed methods of merchandizing coal, from the coal producer's standpoint.

At adjournment, a resolution was adopted by the conference extending its thanks to Dean A. A. Potter and his staff, who conceived and carried out the conference, also to those who presented papers. By unanimous vote, the conference moved that a similar meeting be held annually by all those interested in discussing Indiana fuel problems.

New Standardized Jeffrey Belt Carriers

DURING 1927 Jeffrey belt carriers for Jeffrey belt conveyors were standardized so that the same stands and bases could be used with any one of the three types of pulleys—the plain bearing, the bronze bushed



CROSS-SECTION OF JEFFREY ROLLER-BEARING PULLEY

and the roller bearing. These grey iron pulleys share three characteristics.

First, they are made with open ends. In handling finely reduced clay, sand, lime or cement the dust is apt to collect on closed end pulleys near the bearings, making extra work for the grease seals.

Second, in place of solid ends to insure rigidity of the walls, three arms join the hub and roll. Between the arms, six ribs provide additional lengthwise rigidity.

Third, the free carbon in the grey iron, it is stated, acts as a rust repellant.

Pulleys with plain or bronze bushed bearings have hubs specially cored out to form large recessed grease pockets connecting with the Alemite pressure lubrication fittings at the end of the hollow shaft. These grease pockets are very useful on long belt conveyors where a few pulleys are often skipped over or neglected at the regular oiling. The reserve supply of grease will last until the next oiling.

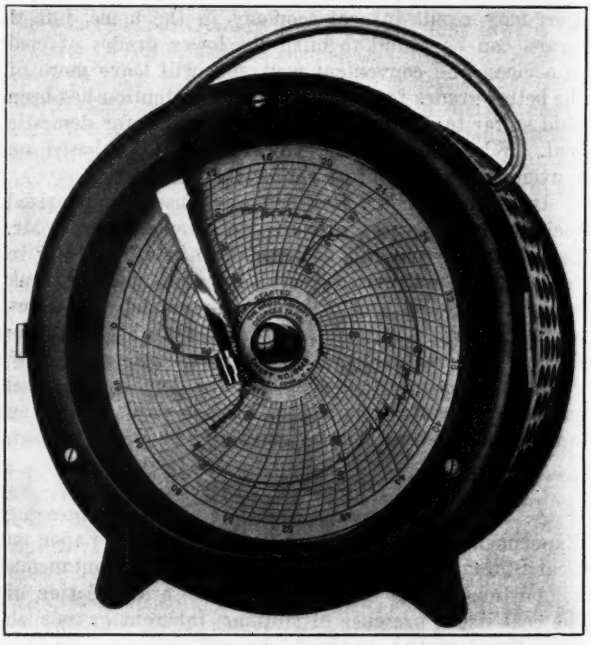
Another advantage claimed for the grease pocket is that grease does not harden in the feed holes. Plain bearing pulleys that are worn may be drilled out and put back into service with new bronze bushings.

For belt conveyors installed to carry materials that are severe on metal bearings—coke breeze for example—Jeffrey makes a roller-bearing pulley pressure greased, accurately fitted and five times grease-sealed.

The labyrinth construction provides five pairs of closely joined metal surfaces to keep powdery abrasives from reaching the bearings. In addition, grease under pressure from the inside flows all dirt outward. Slots in each collar are designed to make possible perfect adjustment and concentric running. These pulleys are made by The Jeffrey Mfg. Co., Columbus, Ohio.

Model 144 Recording Thermometer Uses 4-In. Chart

FOR SECURING an accurate check on atmospheric temperature conditions in such places as cold storage rooms, refrigerating units, dairies, green houses, dwelling houses and public buildings, there has been consider-



RECORDING THERMOMETER USING 4-IN. CHART DESIGNED FOR CHECKING ATMOSPHERIC TEMPERATURES

able demand for a recording thermometer. To meet this demand, a new, small size model of Bristol's recording thermometer has recently been placed on the market. This instrument, as shown in the accompanying illustration, uses only a 4-in. chart, and is designed to give a continuous record for a period of 72 hr.

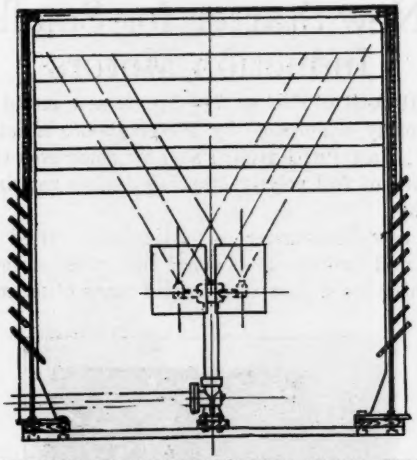
The instrument is designed to be entirely self-contained and is installed by simply placing it wherever temperature readings are desired and without the necessity of running leads or any form of connection. It may be suspended by the handle or mounted on the wall by means of slots in the back of the case.

The measuring element of this recorder consists of a bi-metallic helix designed to be positive in operation and

extremely sensitive to temperature changes. To this element is attached the pen arm which records directly on the chart without any intervening mechanism. The pen arm is inverted and of a special frictionless form with fountain pen to insure a sufficient supply of ink for a complete 72-hour record. The clock is a specially designed Seth Thomas unit, all parts of it being plated with a rust-proof preparation. The clock key is attached to the back of the case in such a way that the clock may be wound without removing the chart or interfering with the operation of the recorder. The case is of aluminum with black enamel as the standard finish, but white enamel can be furnished if desired. Chart ranges are available, for various applications of the recorder, from —20 deg. F. to +125 deg. F. The instrument, known as Model 144 recording thermometer, is being placed on the market by The Bristol Co., Waterbury, Conn.

Marley Small Unit Type Spray Cooling Tower

FOR INSTALLATIONS where small quantities of water must be cooled continuously, as in ice plants, for oil engines and similar applications, the Marley spray cooling tower has been placed on the market.



CROSS SECTION THROUGH MARLEY SMALL UNIT TYPE COOLING TOWER, SHOWING LOUVRE CONSTRUCTION AND ACTION OF COOLING CONE

This is designed for capacities up to 100 g.p.m., the capacities being varied by changing nozzle capacities. The unit occupies an area 8 ft. by 8 ft. and is 9 ft. high.

The main support frame of the unit is of cast iron, slotted to hold louver boards without nails, screws or other fasteners and designed so that the boards may be removed or replaced quickly. One of the principal features of the unit is the Marley cooling cone, as shown in the illustration. This consists of a standard open type Marley nozzle within an open cylinder, the latter mounted on the nozzle and concentric with it. Four of these cones assembled on a special group fitting constitute the spray equipment within the tower. When the nozzle operates, the upward flow of water is intended to induce an inward and upward flow of air through the cylinders to increase circulation and insure thorough cooling. This cooling tower is manufactured by Power Plant Equipment Co., Kansas City, Mo.

Gasoline Three-Speed Crane Features Automotive Shift

DESIGN FOR flexibility equal to that of steam cranes is one of the features of the new "American" gasoline three-speed crane, which has an automotive shift that works just like the transmission on an automobile low gear for a powerful start, intermediate for

NEW GASOLINE ENGINE CRANE HAS AUTOMOTIVE 3-SPEED DRIVE

average crane work and traveling and high gear for rapid traveling.

The new crane, shown herewith, features many modern engineering principles of design. The machinery deck revolves on 20 bronze bushed conical rollers, to make slewing easier and to reduce friction. The machinery deck is locked to the car body at the outer circumference of a bull gear by an interlocking gib ring to distribute the load and stress. The car body is of structural steel with Bethlehem girder beam side sills and solid semi-steel center casting to support the revolving mechanism, while the transmission is of the universal joint automobile type. Capacities are from 12 to 30 t. This new unit is a product of American Hoist & Derrick Co., St. Paul, Minnesota.

New Die Stock for Brass Pipe

OF INTEREST to plumbers, pipe-fitters and others who use brass pipe, is the announcement by The Oster Manufacturing Co., Cleveland, Ohio, of a tool specially designed and built for threading brass pipe. Patterned after the Oster Bull Dog die stock, this new Oster tool has automatic, quick-opening dies to eliminate necessity for backing-off over the finished thread. The dies can also be quickly adjusted to cut deep or shallow threads. Dies especially ground for cutting brass, are another feature of the new tool. A brass face plate, stamped "For Brass Pipe Only," identifies this tool.

P. G. & E. Co. Adds 35,000-Kv.a. Unit at Oakland

By Charles W. Geiger

ADDITIONS ARE NOW being made to the Oakland steam plant of the Pacific Gas and Electric Co., at First and Grove Streets, involving an expenditure of approximately $2,750,000.00. The work includes the removal of a 12,000-hp. turbine and eight 750-hp. boilers and replacing them with two 3400-hp. Babcock & Wilcox boilers and one General Electric high pressure steam turbine generator of 50,000-hp. capacity.

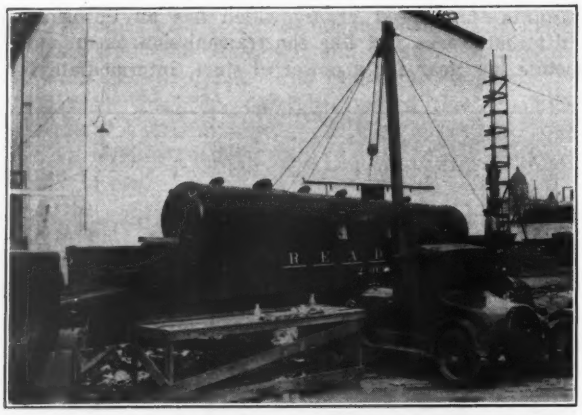


FIG. 1. UNLOADING STEAM DRUM FOR ONE OF NEW BOILERS AT OAKLAND

Electric energy is now delivered to the East Bay cities over hydro-electric transmission lines through three primary channels, i. e., through lines entering at Crockett, Antioch, and Newark. These lines are interconnected with 28 hydroelectric plants in the Sierras and the steam plant at Oakland. Capacity of the steam-electric or stand-by plant at Oakland, through this new installation, will be approximately 83,000-hp.

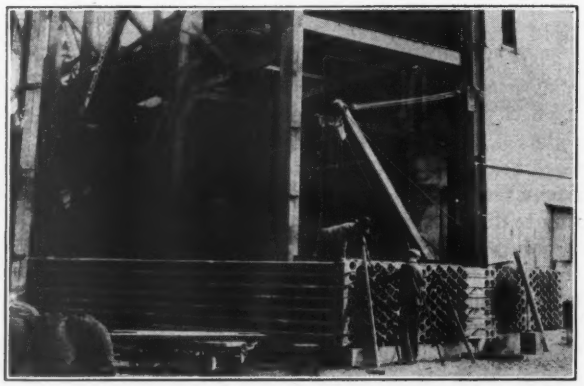


FIG. 2. TUBES AND HEADERS FOR NEW OAKLAND BOILERS

The new equipment is designed in accordance with the most advanced practices in steam plant engineering. The building housing the boilers is of steel 58 ft. wide and 124 ft. long. The boilers are set back to back, with a self-supporting steel stack 16 ft. by 150 ft. Furnace walls are water cooled. Salt water is used for condensing purposes, being pumped from the Oakland estuary and returned to it at the rate of 60,000 g.p.m. when the unit is operating at full load. To provide for revolving screens and an additional pump, a 40-ft. extension was constructed to the existing salt water sump. In order to keep the plant in operation while the installations were being made, a temporary stop-log bulkhead was built across one end of the existing sump, which was removed after the new work was completed.

Boilers operate at 450-lb. pressure, each boiler being equipped with 20 Peabody oil burners. Each boiler has a heating surface of 35,453 sq. ft. Each furnace will be supplied with approximately 100,000 cu. ft. of free air per minute, supplied to the burners at a pressure of 3.8 in. of water at 70 degrees F.

There are two Cameron feedwater pumps, six-stage, 1200-g.p.m. each, operating at 1750 r.p.m. against a head of 570 lb.

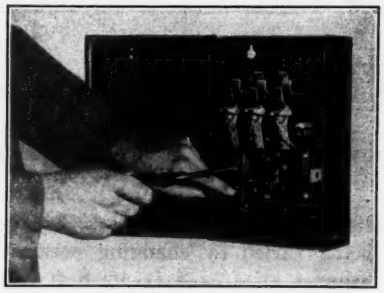
There is a Best water softening plant with a capacity for softening 100,000 lb. of water per hour. Ordinarily water is used from the company's own wells, city water being used as a standby. Swartwout feedwater heaters are used in connection with the water softening plant.

The generator is a General Electric unit of 35,500 kv.a. capacity, operating at 1800 r.p.m., 12,000 v., 3 phase, 60 cycles.

New Starter for Small Induction Motors

WITH A RATING of 7½ hp., a new motor starter recently announced by Westinghouse Electric and Mfg. Co., East Pittsburgh, Pa., now completes the company's line of full voltage starting devices ranging from 1 to 75 hp.

This new Linestarter is particularly suited for the starting and protection of small induction motors driving machine tools, pumps, fans and many other machines where remote control with complete protection to operator, motor and machine is desired. It can also be used as a magnetic primary switch for wound rotor motors within its capacity. It provides an unusually desirable feature in its adaptability to either hand or automatic reset after an overload. It comes equipped with hand reset of the thermal overload relay, but if automatic reset is desired the hand reset lever can readily be removed and automatic reset obtained. Automatic reset has many desirable advantages since the modern tendency is to mount these small starters within the base



NEW WESTINGHOUSE MOTOR STARTER

of the machine they control, in which case provision for hand reset might be difficult to obtain.

Thermal overload protection is provided in this Linestarter as in the other Linestarters of larger capacity. The thermal operating elements consist of the reliable high temperature thermostatic metal strips which are deflected due to heat from heater elements when the motor is overloaded.

Combustion Engineering Corp. Elects Officials

GEORGE E. LEARNARD, President of International Combustion Engineering Corporation, 200 Madison Avenue, New York, announces the resignation of Joseph V. Santry as president of Combustion Engineering Corporation, an American subsidiary of International Combustion Engineering Corporation, and the election of H. D. Savage, for many years vice-president, as president to succeed Mr. Santry.

George T. Ladd has been elected vice-chairman of the Board of Directors of Combustion Engineering Corporation.

Mr. Ladd has achieved marked success in the design and manufacture of steam boilers, especially in connection with large units such as those installed at the Fordson plant of the Ford Motor Co. and at the Kip's Bay Station of the New York Steam Corporation. Mr. Ladd is president of the Ladd Water Tube Boiler Co. and of the Heine Boiler Co.

H. D. SAVAGE

Mr. Savage has been identified with the development of pulverized fuel burning equipment since its inception. Prior to his entry into the pulverized fuel field, he was the active head of the Ashland Fire Brick Co., in which capacity he participated in the organization of the Refractory Manufacturers' Association and served as its first president. In 1914 he became vice-president of the American Arch Co. and, 2 yr. later, vice-president of the Locomotive Pulverized Fuel Co. When the Combustion Engineering Corporation purchased the Lopulco Pulverized Fuel Systems in 1920, Mr. Savage became associated with this organization as the directing head of the Pulverized Fuel Division.

In addition to the presidency of Combustion Engineering Corporation, Mr. Savage holds the following offices in subsidiary companies of International Combustion Engineering Corporation: President of the Dry Quenching Equipment Corporation and of the Combustion Engineering Corporation, Ltd., of Canada; vice-president of the Ladd Water Tube Boiler Co. and of Raymond Brothers Impact Pulverizer Co. Mr. Savage is a member of the American Society of Mechanical Engineers, American Society of Mining and Metallurgical Engineers and the Franklin Institute. He is the author of numerous papers and technical articles.

GEORGE T. LADD

A. S. M. E. Plans Spring Meeting at Pittsburgh

FOR THE SPRING MEETING of the American Society of Mechanical Engineers to be held at Pittsburgh, Pa., May 14-17, a varied and extensive program has been arranged by the Committee on Meetings and Programs. In planning this meeting, the committee has adhered to the principle that discussion is a most important feature of a meeting and that ample provision should be made for it. At the dinner to be held on Wednesday afternoon, May 15, the Holley Medal will be presented to Elmer A. Sperry for his achievements in the invention of the gyroscope. Other entertainment features are planned. The Engineers Society of Western Pennsylvania and the Pittsburgh section of the American Ceramic Society are co-operating in the planning of this meeting.

On Monday morning, May 14, simultaneous sessions will deal with Fuels and Heat Flow, Management, and subjects of general interest. F. G. Cutler will present a paper on Combination Firing of Blast Furnace Gas

and Pulverized Coal. H. G. Reist will discuss Plate Steel Rotor Design for an Electric Generator and a paper on Reciprocating Dry Vacuum Pump will be given by W. S. Weeks and P. E. Letchworth.

On Tuesday morning, May 15, simultaneous sessions will be held on Seamless Tubing and Hydraulic subjects. In the latter division, a long distance recording water level gage will be described by E. B. Strowger and a paper on Computation of the Tail Water Depth of the Hydraulic Jump in Sloping Flumes will be given by Robert W. Ellms.

For the afternoon, an inspection trip through the plants of the U. S. Steel Corp. plants is scheduled.

On Wednesday morning, sessions will be held covering Machine Shop Practice, Applied Mechanics, Glass and Engineering Education; while in the afternoon an inspection trip will be made to the plants of the Westinghouse Electric & Mfg. Co.

Thursday morning, simultaneous sessions on Materials Handling, Central Station Power, Alloys and Applied Mechanics will occur. In the Central Station Power Group will be papers by H. B. Brydon on Some Economic Factors in Power Station Design by George Orrok on High Pressure Steam Boilers. In the afternoon an inspection trip will be made to the American Window Glass Co., Jeannette, Pa.

Those who are planning to attend the A. S. M. E. spring meeting can secure return-fare railroad certificates and for further details of the meeting should communicate with T. A. Peebles, Chairman of the Committee on Information and Registration, William Penn Hotel, while data on hotel accommodations may be obtained from K. F. Treschow, Chairman Hotel Committee, William Penn Hotel, Pittsburgh, Pa.

News Notes

At the 16th annual meeting of the Chamber of Commerce of the United States, to be held in Washington, D. C., May 7 to 11, of special interest to power plant executives will be a luncheon meeting at 1 p. m. on Tuesday, May 8, in the George Washington room of Washington Hotel in charge of Matthew S. Sloan, president of the Brooklyn, N. Y., Edison Co. The topic to be considered is Power and Prosperity.

Organized Effort for Sound Legislation will be the subject of an address by Benjamin L. Young at the general session, 9:40 a. m. Wednesday, May 9, in the council chamber of the Chamber of Commerce building.

At the Wednesday luncheon meeting on Finance, Taxation and Banking will be considered under direction of John G. Lonsdale, president of the National Bank of Commerce, St. Louis.

Thursday morning, at the general session, W. E. Humphrey, chairman of the Federal Trade Commission, will speak on its organization and work, and at the annual dinner, Thursday evening in Washington Auditorium, with Owen D. Young, chairman of the board of General Electric Co. presiding, addresses will be made by Dr. Alberto Pirelli, president of the International Chamber of Commerce, and by Lewis E. Pierson, president of the Chamber of Commerce of the United States.

At the general session on Friday morning, the topic What Teamwork Means to Various Industries will be considered by prominent men in those industries, Natural Resources Production being treated by Matthew S. Sloan.

On April 4, the Board of Engineers and Geologists appointed by the district attorney of Los Angeles to investigate the St. Francis Dam disaster reported to the coroner's jury that the dam collapsed because of a defective geological foundation. The report asserts that there is no evidence of earth movement or of destruction by dynamite and says that, because the geological formations were not satisfactory, the dam should not have been located where it was. On April 5, Surveyor Hemberg, of the Los Angeles Bureau of Power and Water, told the jury that the whole western side of the canyon to which the dam was anchored has moved since it was surveyed preparatory to the construction of the dam. Mr. Hemberg was introduced as a witness to refute testimony tending to show that the dam was placed on a faulty formation.

Stone and Webster, Inc., 49 Federal St., Boston, Mass., has been authorized by I. E. Moultrop, chief engineer of The Edison Electric Illuminating Co. of Boston to design and construct extensions to the switch house and boiler house at the Charles Leavitt Edgar Station at Weymouth, Mass.

The Brown Instrument Co., Philadelphia, Pa., announces that it has secured larger quarters for its Detroit branch, at 576 Maccabee Bldg., Detroit, Mich. This office is in charge of R. W. Mayer, district manager.

D. O. James Manufacturing Co., Chicago, Ill., announces the addition to its sales department of R. C. Bird in the capacity of traveling sales manager. Mr. Bird was formerly with the Chain Belt Co. of Milwaukee, Wis.

In connection with a construction and improvement program for 1928, to cost about $2,000,000, the United Gas Improvement Co., Broad and Arch Sts., Philadelphia, Pa., is arranging for early work on a number of its expansion features. These include new equipment at the gas generating plant at Richmond and Tioga Sts., coal handling and gas pumping machinery at the Point Breeze generating plant and extensions to distributing system and booster stations at different parts of the city.

Henry F. Schmidt, consulting engineer of the Westinghouse Electric & Manufacturing Co., South Philadelphia Works, has been awarded the medal of the American Society of Naval Engineers for the best article submitted during the year 1927. Besides being awarded a gold medal, Mr. Schmidt was given an honorary life membership in the Society and a cash prize for his paper entitled "Some Screw Propeller Experiments with Particular Reference to Pumps and Blowers."

Dampney Co. of America, Hyde Park, Boston, Mass., announces that sale of its products in North Carolina, South Carolina, Florida, Tennessee, Georgia, Alabama, Mississippi and Louisiana will be handled by Neville & Cleary, Inc., Candler Bldg., Atlanta, Ga., with branches in New Orleans and Tampa.

J. L. Lysaght, 1336 E. 13th St., Des Moines, Ia., for many years combustion engineer for the Des Moines City Railways Co., Des Moines, Ia., has recently opened consulting engineering offices of his own, specializing

in domestic and power plant combustion practice. Mr. Lysaght is one of the few combustion engineers who pioneered in the successful utilization of Iowa coal and many years of experience in this field have earned him an enviable reputation.

R. H. BALLARD, formerly executive vice president and general manager of the Southern California Edison Co., was elected president by the directors following the stockholders' annual meeting in Los Angeles on March 16. John B. Miller, who has served for many years as president and chairman of the board, was elected to the position of chairman, and George C. Ward was made executive vice-president.

HARLAN W. BIRD, representative of the M. A. Hofft Co. of Indianapolis, Ind., for the Chicago District, has also been appointed District Representative for Northern Illinois and Northern Indiana by the Bayer Co. of St. Louis, Mo. His offices will remain in 1926 Conway Building, Chicago.

GREAT WESTERN POWER CO., San Francisco, Calif., has applied for permission to acquire a controlling interest in the Feather River Power Co., San Francisco.

HOLYOKE WATER POWER CO., Holyoke, Mass., is perfecting plans for a hydro-electric development on the Connecticut River, for which approval has been granted by the War Department, to have an initial capacity of about 40,000 hp.

TOTAL PRODUCTION of soft coal during the week ending March 3, according to a recent report from the Department of Commerce, Bureau of Mines, including lignite and coal coked at the mines, is estimated at 10,044,000 net tons; compared with the output in the preceding week this is a decrease of 133,000 t., or 1.3 per cent.

Catalog Notes

REEVES PULLEY CO., Columbus, Ind., in a four-page illustrated folder, discusses the details of the new Reeves variable speed transmission.

DELTA-STAR ELECTRIC CO., 2400 Block, Fulton St., Chicago, Ill., is issuing a leaflet describing solderless connectors of the rigid stud compression type.

RESEARCH STAFF of E. F. Houghton & Co., Philadelphia, Pa., is sending out the first general edition of a magazine entitled Black and White. It is a 50-page book containing engineering data on belting, corrosion, lubrication and other subjects.

SCHUTTE & KOERTING CO., Philadelphia, Pa., is issuing a new and completely revised edition of bulletin 4-P, covering water jet exhausters and compressors. The new edition contains much information on capacities, application and prices that was not given in the previous section.

IN AN ATTRACTIVE 12-page bulletin, the American Engineering Co., Philadelphia, Pa., describes and illustrates the details of the Taylor coal burning unit, including the hydraulic drive and automatic control of air supply, the water-cooled wall and the air preheater.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., in Bulletin 1143, describes line start induction motors, normal torque, Type ARX, equipped either with sleeve or roller bearings.

QUIGLEY FURNACE SPECIALTIES CO., INC., 26 Cortlandt St., New York, has just issued bulletin No. 301, describing the new Quigley Bitumen gun for shooting hot or cold materials for coating metal, concrete, stone and other surfaces. This gun was recently described in detail in these columns.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly at Chicago, Ill., for April 1, 1928.

State of Illinois, } ss.
County of Cook. }

Before me, a Notary in and for the State and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse side of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, R. E. Turner, Chicago, Ill.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
K. L. Rice, Chicago, Ill.
Charles S. Clarke, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has not reason to believe that any other person, association, or corporation has any interest, direct or indirect, in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is..... (This information is required from daily publications only.)

Chas. Sanford Clarke, Secretary.

Sworn to and subscribed before me this 27th day of March, 1928.

Eddie H. Kahl.

(My commission expires March 20, 1932.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classication), Washington, D. C., and retain the other in the files of the post office. The publisher must publish a copy of this statement in the second issue printed next after its filing.

Power Plant Construction News

Ala., Huntsville—The Erwin Mfg. Co., Huntsville, plans the installation of power equipment in a proposed one-story addition to textile plant, to cost about $100,000.

Ark., Hampton—Ira Varnell, Varnell Lumber Co., plans construction of electric light and power plant for local commercial service, reported to cost more than $50,000 with equipment. A franchise has been secured.

Calif., Corona—The Blue Diamond Co. plans installation of electric power equipment in connection with proposed rebuilding of rock-crushing plant in the Temescal Canyon, recently destroyed by fire with loss of about $100,000.

Calif., Santa Monica—The Douglas Co., 2435 Wilshire Boulevard, Santa Monica, plans installation of power equipment in proposed one and two-story aircraft manufacturing plant at 2918 Ocean Park Boulevard, 240 by 375 ft., reported to cost close to $90,000.

Colo., Pueblo—The Southern Colorado Power Co., Pueblo, plans extensions and improvements in local steam-operated electric power plant, and additions to transmission lines. A fund of $275,000 has been appropriated for the work. W. N. Clark is general manager.

Ga., Wallacoochee—The W. B. Miller Lumber Co., Valdosta, Ga., is at the head of a project to construct and operate a local ice-manufacturing and cold storage plant reported to cost more than $30,000 with equipment.

Idaho, Lewiston—The Pacific Power & Light Co., Portland, Ore., is planning extensions and improvements in the Lewiston-Clarkson district to cost about $90,000, including new power substation at East Lewiston, transmission and distributing lines. Howard Cooper is manager at Lewiston.

Ill., Chicago—The Commonwealth Edison Co., 72 West Adams Street, has taken out a permit for the construction of a one-story and basement power substation, 60 by 60 ft., at 200 North Harding Avenue, to be known as the Maypole substation. Work will proceed immediately.

Ill., Chicago—The Jefferson Ice Co., 1515 Bickerdike Avenue, has plans for a one-story ice-manufacturing plant at 2248 North Natches Avenue, to cost in excess of $45,000. G. L. Lehl, 3810 Broadway, is engineer.

Ill., Mattoon—The Brown Shoe Co., St. Louis, Mo., will install electric power equipment in its proposed three-story factory on local site. Entire project will cost $250,000.

Mass., Springfield—The City Council has authorized a fund of $234,000, for the installation of a pumping plant for the Wason and Rowland Avenue sewer systems, including purchase of site on Rowland Avenue. Plans will be prepared at once. The city engineer is in charge.

Md., Rowlandsville—The Morocto Roofing Co. plans installation of power equipment in connection with proposed rebuilding of local mill, destroyed by fire April 5, with loss estimated in excess of $350,000.

Mich., Bay City—The Chevrolet Motor Co., Flint, Mich., a division of the General Motors Corporation, Detroit, will install power equipment in a proposed one-story plant unit on North Madison Street, to cost $400,000. Wright & Nice, 4339 South Saginaw Street, Flint, are architects.

Miss., New Albany—The Inland Utilities Co., Kansas City, Mo., is concluding negotiations for purchase of local municipal power plant and plans extensions and improvements in this section, including transmission line construction.

Mo., St. Louis—The American Car & Foundry Co., Syndicate Trust Building, St. Louis, and 30 Church Street, New York, will install power equipment in proposed addition to its plant on Dorcas Street, to cost more than $200,000.

Mont., East Helena—The City Council plans installation of pumping equipment in connection with proposed extensions and improvements in municipal waterworks for which a bond issue of $100,000 is being arranged.

N. C., Kings Mountain—The Board of City Commissioners plans the installation of power equipment in connection with proposed extensions and improvements in the municipal waterworks. The Carolina Engineering Co., Wilmington, N. C., is engineer.

N. C., Wadesboro—The Jepson Art Weaving Co., care of the Wadesboro Chamber of Commerce, recently organized by Frank Bennett, L. D. Robinson, both of Wadesboro, and associates, plans installation of power equipment in a proposed local rayon mill, estimated to cost about $200,000. A boiler plant is also being considered.

N. D., Westhope—M. A. Erickson, Rugby, N. D., operating the Rugby Light & Power Co., plans extensions and improvements in local power plant, including the installation of additional equipment. Additions will be made in transmission lines.

N. J., Bayonne—The Bayonne Bolt & Nut Corporation, Trask Avenue and First Street, plans the installation of power equipment in connection with proposed rebuilding of its plant destroyed by fire April 5, with loss reported in excess of $200,000.

N. J., Stone Harbor—The Borough Council plans the installation of pumping equipment in connection with a proposed sewage disposal plant, for which a fund of about $300,000 is being arranged. Remington & Vosbury, 509 Cooper Street, Camden, N. J., are engineers.

N. Y., Binghamton—Afga-Ansco Mfg. Co., 23 Charles Street, plans installation of power equipment in a proposed two and three-story addition to its photographic material and camera factory. Entire project will cost in excess of $500,000.

N. Y., Brooklyn—The Todd Shipyards Corporation, 25 Broadway, New York, will install a pumping plant, with electric operated pumping units; motors, control apparatus and other electric power equipment, in connection with a new drydock at its plant at Erie Basin, Brooklyn. Entire project will cost close to $2,000,000.

N. Y., Buffalo—The Trico Products Co., 625 Ellicott Street, manufacturer of automobile specialties, will build a boiler plant in connection with a five-story factory addition. Entire project will cost about $200,000.

Ohio, Dayton—The Miami Development Co., care of O. E. Howland, Dayton Power & Light Co., has acquired property on Eaker Street, near Perry Street, and plans construction of multi-story cold storage and refrigerating plant, to cost more than $150,000.

Pa., Hazleton—The Reading Coal & Iron Co., Reading Terminal, Philadelphia, is planning the electrification of its coal-mining plants at Hazleton, Wilkes-Barre and vicinity, including installation of substation apparatus, motors, hoists, etc. Negotiations are in progress with the Pennsylvania Power & Light Co., Allentown, Pa., for central station service.

Tenn., Nashville—The Victor Chemical Co., 343 South Dearborn Street, Chicago, Ill., is reported planning a steam power plant in connection with a projected plant on tract of land acquired at West Nashville, for acid production. Entire enterprise will cost more than $850,000.

Texas, Plainview—The Texas Utilities Co., Plainview, is perfecting plans for early construction of a super-power steam-operated generating plant in this vicinity, for service in the Panhandle and Eastern New Mexico districts. A site will soon be selected. Entire project is reported to cost more than $400,000.

Va., Bedford—The Bedford Woolen Co., Inc., Bedford, plans installation of power equipment in connection with proposed rebuilding of portion of mills destroyed by fire April 5, with loss reported in excess of $250,000.

Va., Roanoke—The Stauffer Chemical Co., Grand Central Terminal, New York, is reported planning the construction of a boiler plant in connection with a projected local mill, entire project to cost more than $175,000.

Vt., Barnet—The New England Power Co., Worcester, Mass., is reported planning a hydroelectric power plant on the Connecticut River, vicinity of Barnet, with an initial output of about 50,000 hp. Project is reported to cost more than $1,500,000 with transmission lines.

Wash., Wenatchee—The Wenatchee Produce Co., North Wenatchee Avenue, will soon take bids for the construction of two cold storage and refrigerating plants, one five-story, 100 by 100 ft., and the other two-story, 75 by 100 ft., reported to cost in excess of $160,000 with equipment. R. C. Stockton, Perkins Building, Tacoma, Wash., is engineer.

Wis., Randolph—The City Council will make extensions and improvements in municipal electric power plant, including installation of generator, boiler, switchboard and other equipment, estimated to cost $58,000, in which amount a fund is available.